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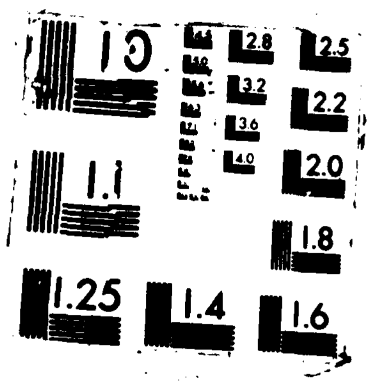
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SMALL BOAT TEST PLAN

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AND
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FINAL REPORT
APRIL 1987

Prepared for:

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16. Abstract

Standard tests to document the performance of Coast Guard small craft are outlined in this report. The test procedures for various calm and rough water aspects of small craft performance form general guidelines to be used in the writing of specific test plans for testing existing Coast Guard boats and candidate replacement craft. The Small Boat Test Plan is an extension, and in some cases an adaptation, of the existing General Test Plan for Advanced Marine Vehicles, with the focus on the special needs and requirements of small craft.

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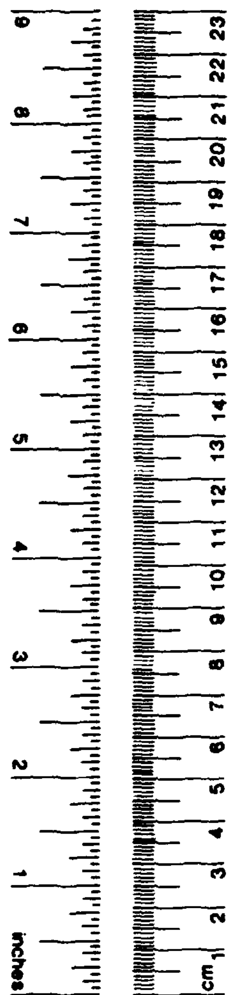
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

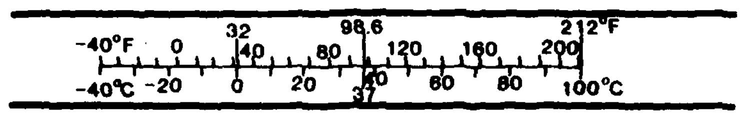
Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (WEIGHT)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (EXACT)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures. Price $2.25. SD Catalog No. C13.10.286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (WEIGHT)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	0.125	cups	c
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (EXACT)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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LIST OF ILLUSTRATIONS

1.0 INTRODUCTION

1.1 Purpose of the Small Boat Test Plan (SBTP)

The objective of this effort is to compile and document comprehensive procedures which will be used for acquiring data on the performance and suitability of small boat replacements. The purpose for this effort is threefold. The document will provide a means of standardizing the way the Coast Guard looks at candidate small boat replacements which will facilitate a more accurate means of vessel comparison. It will also provide consistency to the full-scale trials program of existing Coast Guard small boats. Lastly, the tests will be described in detail to aid in the writing of specific test plans.

1.2 Background

The Research and Development Center (R&DC) was tasked by Commandant (G-DMT-2) in a statement of work dated 19 January 1981 to undertake the testing of an assortment of advanced marine vehicles and current Coast Guard vessels. Development of this Small Boat Test Plan was one of the requirements of that statement of work.

In 1981 a General Test Plan was written for use in the evaluation of all Coast Guard vessels. However, it did not address the needs of small boats. Research was conducted through journals containing information on foreign practices of small boat evaluations and through interviews of numerous small boat coxswains and crew members on both the Atlantic and Pacific coasts. The Small Boat Test Plan was developed from tests contained in the General Test Plan and through the information obtained through the research.

2.0 MISSION CRITERIA AND OPERATING CHARACTERISTICS

Coast Guard small boats have missions which require performance beyond that of the typical power boat. Prior to developing the Small Boat Test Plan, the small boat mission criteria and operating characteristics were determined. Although it may not be necessary for every small boat to have these characteristics, they were established in order to insure that tests were developed to cover all aspects of the mission performance.

SURVIVABILITY

(1) Self-righting
(2) Operate in surf environment
(3) Operate in heavy weather
(4) Watertight integrity
(5) Reliable equipment and machinery

MANEUVERABILITY

(6) Rapid helm response
(7) Rapid throttle response
(8) Directional stability
(9) Quick acceleration and stopping
(10) Slow speed agility

SPEED

(11) Decreased transit time and sustained speed in a seaway

POWER

(12) Adequate towing capability

SEAKEEPING

(13) Reduced vessel motions

RAPID RESPONSE

(14) Minimum time needed to get underway

RANGE

(15) Adequate fuel supply to perform several missions without refueling

HABITABILITY

(16) Acceptable noise levels
(17) Low vibrations
(18) Acceptable human factors in defined rough seas

VISIBILITY

(19) All around visibility for piloting station
(20) Reduced effects of vision loss from spray, icing, and fogging of windows

MAINTAINABILITY

(21) Minimize time and personnel needed to perform routine maintenance

OPERATIONS EQUIPMENT

(22) Communications: secure comms for ELT mission (VHF, loudhailer, etc.) Navigational: equipment properly placed so that it is functional (compass, Loran, RDF, radar, chart storage, etc.)

WORKING PLATFORM

(23) Adequate space or boarding, towing, and helo operations
(24) Adequate fendering system for boardings and towing operations
(25) Anchoring capability
(26) Towing bitt with sufficient strength and in proper location to be handled by one crew member

ACCOMMODATIONS

(27) Comfortable and secure seating for crew and passengers

FIREFIGHTING/DEWATERING

(28) Capabilities consistent with historical usage

WEAPONS

(29) Secure stowage for standard service issue weapons and associated ELT equipment
(30) Support for military preparedness
(31) Appropriate structural integrity of pilothouse to provide shelter from small arm rounds

3.0 SUGGESTED TEST PRIORITY LIST

Since Small Boat Testing may be conducted for any one of a number of reasons, the Test Director must prioritize the tests to be conducted so that the needs of the test program are met. For instance, if the testing is for acceptance trials of a contractor's vessel, then tests which verify the performance requirements of the contract must have the highest priority.

It is difficult to assign a strict, first-to-last priority list even for the general engineering characterization TECHEVAL's and OPEVAL's which are normally run (and to which this list is applicable), so the tests outlined in this guide have been grouped, based on previous experience and developmental needs, into 3 levels of priority.

The Test Director needs to be flexible, and if no further highest priority testing can be accomplished in a given time frame, as many lower priority tests should be run as possible, to gain the most possible information out of the always limited testing opportunities. (Within groups, tests are listed alphabetically, with no implied priority.)

Tests of the Highest Priority

Directional Stability
Fuel Consumption and Endurance
Helm and Throttle Response
Motion in Waves
Principal Characteristics
Speed Versus Power
Self Righting (if applicable)
Surf Operation (if applicable)
Visibility from the Pilothouse
Watertight Integrity

Tests of Medium Priority

Maximum Maneuvering Speed
Noise Level
Seakeeping Ability - Physiological
Slow Speed Agility
Spiral Test
Tactical Data
Towing Capability

Tests of Low Priority

Vibration Level
Operational Capabilities
Zig-Zag
Anchoring
Maintenance
Adverse Weather Operations
Moment to Heel and Trim
Firefighting
Time to Get Underway
Deck Area and Internal Volume

CONCURRENT TESTING

Figure 1 is a matrix of tests which can be conducted concurrently. Some tests are not included because they are not time limited. These include subjective evaluations where a questionnaire is to be filled out, evaluations involving observations by the test director, and evaluations where the data is acquired from ship's plans.

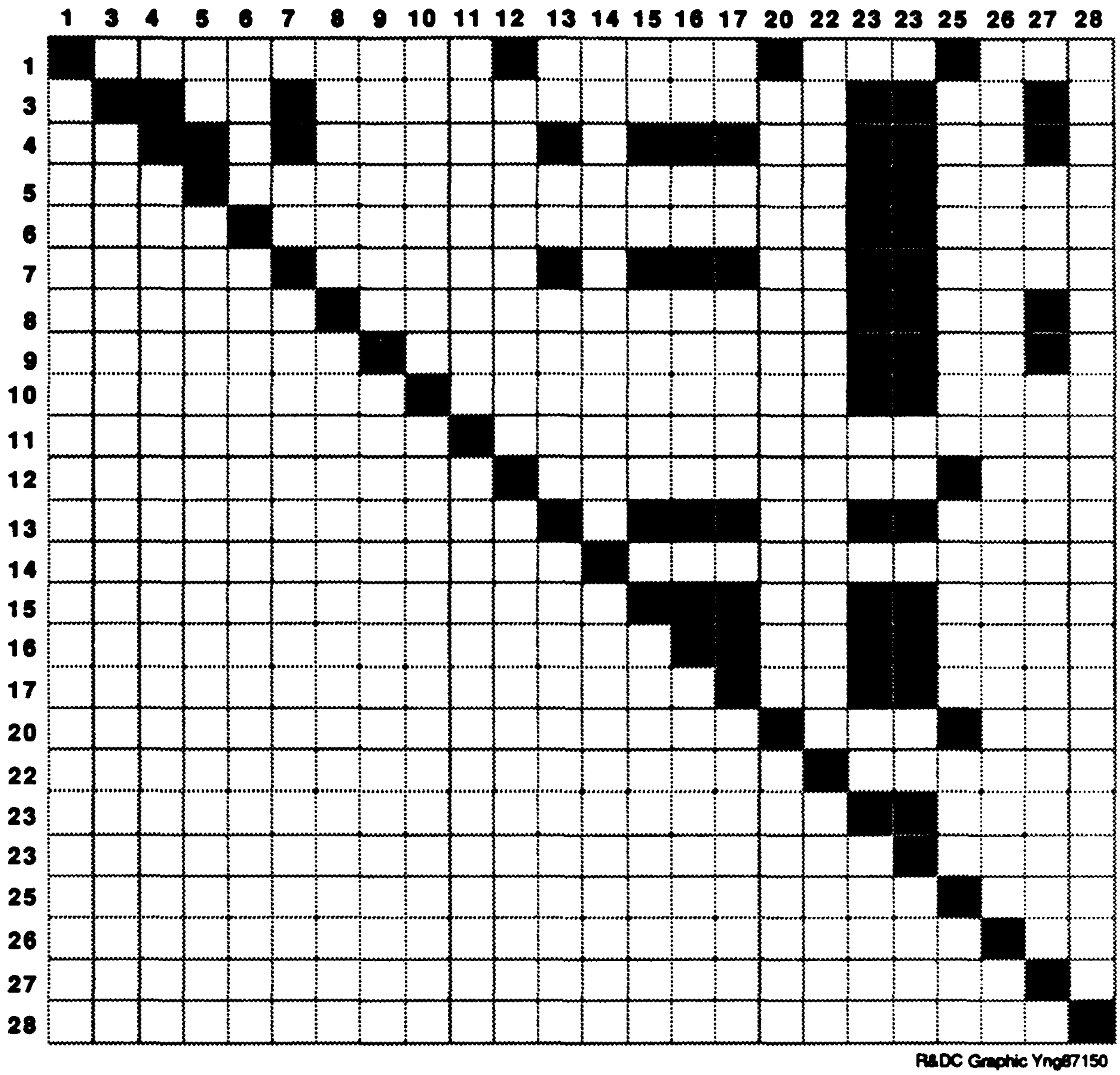


FIGURE 1. Tests Which May Be Conducted Concurrently

TEST NUMBER 1
PRINCIPAL CHARACTERISTICS

OBJECTIVE

To determine the principal characteristics of the marine vehicle and to collect general purpose plans and photographs.

PROCEDURE

Most of the data to be gathered in this test can be obtained from the ship's plans for the vessel being tested. Displacement data should be confirmed by comparing the draft for a known payload (fuel, water, lube oil, cargo, etc.) with the draft predicted from ship's plans. There may be a substantial difference between the payload the vessel was designed to carry and the actual payload it can carry without exceeding its maximum draft.

MEANS OF DETERMINING DATA - The following ship plans are to be obtained from the builder or owner of the vessel:

1. Outboard profile
2. Bow view outboard
3. Inboard profile
4. Deck plans for all decks (if applicable)
5. Midship section
6. Other cross sections showing machinery arrangement
7. Machinery arrangement drawings (for each deck)
8. Curves of form
9. Floodable length curves (only if test 18 is to be conducted)
10. Lines drawing

From these plans the following characteristics are to be determined:

1. Length overall (LOA)
2. Length between perpendiculars (LBP)
3. Maximum beam
4. Hull depth
5. Displacement (light ship)
6. Displacement (full load)
7. Draft (light ship)
8. Draft (full load)
9. Freeboard (maximum and minimum)
10. Minimum operating depth (full load draft plus 1 foot)
11. Radar antenna height (above full load waterline)
12. Height of eye from bridge (5'6" above Pilot House Deck or from normal coxswain's position)
13. Number of persons in crew

DATA FORMS

Form 1A is to be used to record this data. Form 1B is a check-off list of photographs to be taken.

PHOTOGRAPHIC DOCUMENTATION

Photographs of a general purpose nature are to be taken in this test. Some of the photographs may require the use of a helicopter. The photographs required are 35 mm slides and 8-1/2" x 11" prints taken from the following angles:

1. Beam view underway
2. Beam view at the dock
3. Bow view underway
4. Bow view at the dock
5. Stern view underway
6. Stern view at the dock
7. Bow view from 30 degrees to 60 degrees vertical angle
8. 30 degrees to 60 degrees vertical angle views broad on port and starboard bow, port and starboard beam, and broad on the port and starboard quarter
9. Stern view from 30 degrees to 60 degrees vertical angle

The photographs in items 7 through 9 are to be taken with the craft underway. Separate sets of photos should be taken if the craft has two significantly different operating configurations such as foilborne or hullborne in the case of a hydrofoil. Views designated to be taken at the dock can be taken with the vessel dead in the water away from the dock.

Sufficient videotape footage shall be taken so that a summary movie can be made of various craft photographed under this test. The movie will illustrate the differences and similarities between this vessel type and other vessel types. Brief and selective portions of the videotape shall be edited and provided with a voice-over narrative to show, in addition to the requirements above:

1. What the craft is
2. What is its basic performance
3. A record of any interesting evolutions (surf operations, boardings, etc.)
4. Important operational characteristics, problems, and abilities

ANALYSIS OF DATA

The only analysis required in this test is a calculation to determine what actual payload results in the design maximum displacement. This can be computed from the curves of form and the draft for a known payload.

DATA FORM 1A

PRINCIPAL CHARACTERISTICS

VESSEL NAME ________________________________ DATE ______________

RECORDER ___________________________________

PLANS CHECK-OFF LIST (IF ANY PLANS ARE NOT APPLICABLE SO NOTE)

LINES DRAWING ________________ CROSS SECTIONS ________ ________

BOW VIEW ______________________ FLOODABLE LENGTH ______________

OUTBOARD PROFILE ______________ MIDSHIP SECTION _______________

INBOARD PROFILE _______________ CURVES OF FORM ________________

DECK PLANS 3 ____ 2 ____ 1 ____ Main ____ 01 ____ 02 ____ 03 ____

MACHINERY ARRANGEMENTS PLAN ________ PROFILE ________

PRINCIPAL CHARACTERISTICS

LOA ____________________ LBP ____________________

BEAM ___________________ DEPTH __________________

DISPLACEMENT (LIGHT SHIP) ____________ (FULL LOAD) ____________

DRAFT (LIGHT SHIP) ____________ (FULL LOAD) ____________

FREEBOARD (LIGHT SHIP) ____________ (FULL LOAD) ____________

MIN. OPERATING DEPTH OF WATER (FULL LOAD DRAFT +1') ______________

RADAR ANTENNA HEIGHT ____

HEIGHT OF EYE FROM HELM OR COXSWAIN'S POSITION __________________

NUMBER OF CREW ______________________

DATA FORM 1B

PRINCIPAL CHARACTERISTICS

PHOTO CHECK LIST

VESSEL NAME ________________________ DATE __________

NOTE SHOT AND ROLL NUMBER FOR EACH VIEW

	CONFIGURATION	
BEAM VIEW UNDERWAY	______	______
STERN VIEW UNDERWAY	______	______
BOW VIEW UNDERWAY	______	______

VIEWS FROM 30 DEG TO 60 DEG VERTICAL ANGLE UNDERWAY

BOW	______	______
BROAD ON PORT BOW	______	______
BROAD ON STBD BOW	______	______
PORT BEAM	______	______
STBD BEAM	______	______
BROAD ON PORT QUARTER	______	______
BROAD ON STBD QUARTER	______	______
STERN	______	______

VIEWS ON DOCK OR DIW

PORT BEAM	______
STBD BEAM	______
STERN	______
BOW	______

TEST NUMBER 2

DECK AREA AND INTERNAL VOLUME

OBJECTIVE

To determine the available internal volume and deck area of the craft tested.

PROCEDURE

All data for this test will be obtained from the deck plans, lines drawing, and inboard profile. If these plans were not obtained in Test 1, they will need to be obtained from the builder or owner of the vessel.

MEANS OF DETERMINING DATA

Deck areas are to be obtained by measuring the gross deck area of compartments. The volume of these compartments may be calculated by multiplying the deck area by the height between decks taken from the inboard profile. Odd-shaped volumes such as tankage space should be computed using cross sectional areas and Simpson's rule. The following volumes and deck areas are to be determined.

1. Total enclosed volume of hull
2. Total enclosed volume of deckhouse
3. External deck area of each deck
4. Internal deck area of each deck
5. Maximum and minimum deck area or volume which is suitable for the following special uses:

   a. Liquids (fuel, water, lube oil, etc.)
   b. Accommodations (berthing, messing, sanitary, passageways)
   c. Machinery Space
   d. Pilot House, Bridge
   e. Provisions, Stores, and Cargo
   f. Stacks and Uptakes
   g. Ground Tackle (chain locker, winches, etc.)
   h. Operations equipment (towing, firefighting gear, weapons, etc.)

DATA FORMS

Form 2A is to be used to record this data.

ANALYSIS OF DATA

None required.

DATA FORM 2A

DECK AREA AND INTERNAL VOLUME

VESSEL NAME ______________________ DATE ____________

TOTAL ENCLOSED VOLUME OF HULL ____________

TOTAL ENCLOSED VOLUME OF DECKHOUSE ____________

EXTERNAL DECK AREA	MAIN DECK	____________
	01	____________
	02	____________
	03	____________
INTERNAL DECK AREA	03	____________
	02	____________
	01	____________
	Main	____________
	1	____________
	2	____________
	3	____________

SPECIAL USE SUITABILITY	MAX AREA/VOL	MIN AREA/VOL
a. Liquids	____________	____________
b. Accommodations, etc.	____________	____________
c. Machinery Spaces	____________	____________
d. Pilot House	____________	____________
e. Provisions and Cargo	____________	____________
f. Stacks and Uptakes	____________	____________
g. Ground Tackle	____________	____________
h. Operations equipment	____________	____________

TEST NUMBER 3

SPEED VERSUS POWER

OBJECTIVE

To determine the speed/powering characteristics of the vessel under various conditions of load, operating configuration, and equipment disablement.

PROCEDURE

The design speed/power curves for the boat should be obtained if available. The maximum design speed should be obtained from this plan or some other reliable source. Additional data to be collected from plans or observations includes number of shafts, maximum SHP, and propeller characteristics (diameter, pitch, number of blades).

The actual speed/power performance of the vehicle is to be determined by making trial runs at various shaft RPM's. These trials should be conducted at RPM intervals from idle speed up to full power RPM. For outboard powered craft and other vessels where the trim of the propulsion unit and/or the hull can be varied, additional trials at various trim settings should be conducted.

If the displacement of the craft can be varied by more than 10 percent of full load displacement, then trials should be conducted near full load displacement and near light ship displacement. If the craft can operate in two distinctly different configurations (with an air cushion or without, as is the case for SES's), the test should be performed for each configuration. Likewise, certain cases of equipment disablement may be of interest. This could include one shaft locked for a multi-shaft vessel. It could also include an air fan disabled on an SES. In any event, the test procedure will not change although the maximum available power may change. Disabled equipment for this test must be listed in the SBTP.

All trials are to be run on a straight line course with minimal wind, current and wave height (flat calm if possible, particularly for small craft). A water depth greater than 10 $HV/(L)^{1/2}$ is required where:

H = trial draft
V = maximum speed
L = length on waterline

A test area with good LORAN-C coverage is essential if speed is to be determined using LORAN information. The minimum test run at each speed is one mile.

MEANS OF DETERMINING DATA

Shaft horsepower and speed data are desired for this test. For a multi-shaft vessel, the SHP for each shaft is to be summed to obtain the total SHP. The preferred method for collecting SHP data is to install a torque and RPM transducer on each shaft. Vessel speed may be calculated from LORAN-C positions. LORAN-C positions should be recorded with the minimum possible averaging. LORAN-C readings taken 15 seconds apart are considered acceptable.

On boats with outboard engines or other vessels where installation of torsion meters are impossible, speed and RPM data will only be collected. Vessel speed may be determined from an installed speedometer that is sufficiently accurate, a speed test course, or with a radar speed gun. RPM data can be obtained from a stock electric tachometer on the boat which is properly calibrated.

PARAMETERS VARIED AND HELD CONSTANT

For each test run, the shaft RPM will be held constant within the limits of controls. This will result in a constant average speed. It is important that the speed be held as constant as possible since only the average speed can be computed from vessel positions. Shaft torque and RPM are to be recorded at frequent intervals (several times per second if using electronic recording, every 15 seconds, with the recorder averaging mentally if recording by hand). Therefore, average SHP can be computed accurately even with RPM variations.

It is extremely important that near calm conditions prevail during these tests. Wave height should be less than 2 feet, and wind speed must be below 15 knots for WPB size vessels or larger. For small craft, no more than a light chop can be tolerated, and winds should be under 10 knots. When possible, the speed trials should be run with the wind on the vessel's beam. Water current must be below 1 knot. Rudder angle should never exceed 10 degrees. This includes turning the vessel to proceed on an opposite course.

The following data is to be collected:

1. Vessel position at least once every fifteen seconds
2. Exact time of position reading
3. Shaft torque for each shaft at least once per second
4. Shaft RPM for each shaft at least once per second
5. Draft and trim of vessel
6. Operating configuration, including engine and tab trim settings
7. Equipment considered disabled
8. Wave height and direction
9. Wind speed and direction

10. Current conditions from current tables or from other observations such as buoy positions
11. Water depth
12. Temperature and density of the water in the trial area
13. Rudder angle

For outboard engines and other craft where shaft torque measurements are not possible, the following data will be collected:

1. Average shaft or propeller RPM
2. Average speed
3. Draft and trim of vessel
4. Operating configuration, including engine and tab trim settings
5. Wave height and direction
6. Wind speed and direction
7. Current conditions
8. Water depth

INSTRUMENTATION REQUIRED

1. LORAN-C receiver which is capable of providing positions at intervals of 15 seconds or less, is capable of translating the readings to latitude-longitude coordinates, and can be interfaced with a computer data collection system.

2. A real-time clock either integral with the LORAN-C receiver or integral with the computer system recording the data. This clock should be accurate to 1 second.

3. A shaft torsionmeter capable of interfacing with the computer. A shaft torsionmeter is an instrument for measuring the torsional deflection of a shaft over a known portion of its length, while the shaft transmits power from the engine to the propeller. This deflection is proportional to the transmitted torque and can be combined with measured shaft RPM and suitable calibration and physical constants to calculate shaft horsepower.

   Any of the following types of torsionmeters can be used:

   Variable mutual - inductance gauges
   Resistance - wire strain gauges
   Phase - shift gauges
   Permeability - magnetic

   Calibration should be performed in place by jacking the shafts if possible. See SNAME "Code for Sea Trials 1973" for procedures for calibrating torsionmeters.

4. A shaft RPM counter capable of interfacing with the computer.

5. An anemometer for wind speed and direction. Hand recording of data is acceptable.

6. An electronic depth sounder. Hand recording is acceptable.

7. A hydrometer for measuring water density and a thermometer for measuring water temperature. Hand recording is acceptable.

8. Computer data system for recording data.

9. Rudder angle transducer.

For outboard engines and other craft where shaft torque measurements are not possible, the following instrumentation is required:

1. Speedometer (accurate 1 mph) or radar gun if a speed test course is not used.

2. Tachometer to determine shaft or propeller RPM.

DATA FORMS

Form 3A is to be used to record the data not stored on computer disks or tape.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

Shaft torque and SRPM data are to be processed together with appropriate constants to determine shaft horsepower. The ship position data is to be used to determine average ship speed.

A curve showing speed versus horsepower is to be drawn based on the results of the speed runs. Notation is to be included on this curve of the draft and trim of the vessel, operating configuration, equipment disabled, sea and wind conditions, water depth, water temperature and density.

A curve of speed versus SRPM will also be drawn for use in estimating speed using SRPM.

DATA FORM 3A

SPEED VERSUS POWER

VESSEL NAME ______________________ DATE ____________

RECORDER ______________________

LOCATION ______________________

DRAFT FWD ____________

AFT ____________

OPERATING CONFIGURATION ______________________

EQUIPMENT DISABLED ______________________

____

WAVE HEIGHT ____________ WAVE DIRECTION ____________

WIND SPEED ____________ WIND DIRECTION ____________

CURRENT SPEED ____________ CURRENT DIRECTION ____________

RUN #	START TIME	TAPE COUNTER	END TIME	TAPE COUNTER	COURSE	SPEED	SRPM	HP

WATER DEPTH ______________________

TEMPERATURE WATER ______________________

DENSITY OF WATER ______________________

DATA DISKS/TAPE NO. ______________________

TEST RUN NOS. ______________________

TEST NUMBER 4

FUEL CONSUMPTION AND ENDURANCE

OBJECTIVE

To determine main engine fuel consumption. The amount of usable fuel which can be carried will be obtained and from this data the endurance for various operating conditions will be computed. Computing endurance requires that Test 3, speed versus power, be performed as well.

PROCEDURE

Data for this test can be collected during the speed versus power runs of Test 3 or any other operations in which the shaft horsepower is varied over its full range. Main engine fuel consumption will be compared to shaft horsepower.

MEANS OF DETERMINING DATA

Shaft horsepower and fuel flow data are required for this test. Shaft horsepower should be determined using a shaft torsionmeter and SRPM counter as described in Test 3. Fuel flow should be measured at a point in the fuel lines where fuel flow to a single engine or single auxiliary is present. For many diesel engines, the fuel is recirculated to the tank for injector and fuel pump cooling. In these cases, both the fuel to the engine and from the engine must be measured. Main engine fuel consumption should be measured over a range of speeds from idle through maximum power so that curves can be drawn.

For most engines, fuel consumption varies with both horsepower and torque. Because of this, fuel consumption data should be collected with the vessel traveling in a free-running, transit condition. Additional data can be collected for different operating configurations and during towing if desired.

Determining the fuel consumption of auxiliaries is not as critical as determining main engine fuel consumption. Therefore, appropriate indicators of engine or other auxiliary load can be recorded by hand while measuring fuel flow rate.

The amount of usable fuel carried should be determined from ship's plans.

PARAMETERS VARIED AND HELD CONSTANT

For each test run the shaft RPM should be held constant for a sufficient time to accurately measure fuel flow. This time will be largely dependent on the type of fuel meter used. The time required for a one-mile speed run is more than sufficient time for most fuel meters. Test runs should be made from idle RPM to full power in the free running condition. Additional runs should

be made if the craft has two or more significantly different operating configurations.

Wave height should be less than 4 feet for WPB or larger size craft during these trials, and under 2 feet for small craft, but they can be run in higher waves if necessary. Wind and current conditions will have little effect.

The following data are to be collected:

1. Shaft torque for each shaft at least once per second (every 15 seconds if recording by hand)
2. Shaft RPM for each shaft at least once per second (every 15 seconds if recording by hand)
3. Fuel flow
4. Operating configuration
5. Wave height
6. Water depth
7. Fuel oil temperature near flow meters (for density)
8. Fuel type

INSTRUMENTATION REQUIRED

1. A shaft torsionmeter is required which can be interfaced with the computer data-gathering system
2. A shaft RPM counter capable of interfacing with the computer data-gathering system
3. Flow measurements may be made using either clamp-on ultrasonic flow meters or in-line positive displacement meters, turbine meters, variable area meters, or measuring flow nozzles.
4. Water depth should be measured by an electronic depth sounder. Hand recording of data is acceptable.
5. Power indicators for auxiliary devices should be taken from existing instrumentation and may be recorded by hand.
6. A thermometer in the fuel line near the gauges is required to determine fuel density. Hand recording of the temperature is adequate.
7. Computer data system for recording data.

DATA FORMS

Form 4A is to be used to record the data not stored on computer disks or tape.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

Shaft torque and SRPM data are to be processed together with appropriate constants to determine shaft horsepower. Fuel

consumption in weight units should be computed based on flow to and from the engine or device and from the temperature and type of fuel.

A curve showing fuel consumption versus power for each main and auxiliary engine or device is to be developed. Separate curves will be drawn for each operating configuration or for high torque loads such as towing conditions. Notation will be made on the curves of the operating configuration, wave height, and water depth.

Vessel endurance versus speed curve will be drawn using the results of this test and Test 3. This will only be done if Test 3 was performed. Notation will be made on these curves of operating configuration, minimum water depth, and usable fuel carried.

DATA FORM 4A

FUEL CONSUMPTION AND ENDURANCE

VESSEL NAME ______________________________ DATE ________________

RECORDER _________________________________

OPERATING CONFIGURATION ____

WAVE HEIGHT __________________ WAVE DIRECTION __________________

RUN #	TIME	COURSE	PORT SHAFT RPM	PORT SHAFT HP	STBD SHAFT RPM	STBD SHAFT HP

RUN #	TIME	PORT MAIN ENGINE In Temp Deg.	PORT MAIN ENGINE In Flow GPM	PORT MAIN ENGINE Out Temp Deg.	PORT MAIN ENGINE Out Flow GPM	STBD MAIN ENGINE In Temp Deg.	STBD MAIN ENGINE In Flow GPM	STBD MAIN ENGINE Out Temp Deg.	STBD MAIN ENGINE Out Flow GPM

FUEL TYPE ____________________ WATER DEPTH ________________________

TEST NUMBER 5

TOWING CAPABILITY

OBJECTIVE

To determine the towline pull of the vessel in a static (bollard) pull condition and in an at-sea towing condition.

PROCEDURE

Bollard Pull

A line of adequate strength to safely withstand the full power bollard pull of the vessel is to be used. This line will be connected between the vessel and a shore anchoring point of sufficient strength. The towline pull will be measured by a load cell installed in this line. If the vessel being tested was not designed for towing, the best anchor point on the ship may not be apparent. If no adequate anchor point is available, this test should not be attempted. The strength of the towing bitt onboard the vessel should also be considered, and the tests must be discontinued **immediately** if the safe working load of any of the loaded components is reached.

A water depth of at least five times the vessel's draft is highly desirable. If water of this depth is not available the test can be conducted but the results will be affected due to the restriction in water flow to the propeller. In any case, sufficient room behind the vessel must be allowed so that the wake is not restricted and no circulating flow is established.

Bollard pull readings will be made for at least five levels of power between idle power and full power. Towline force must be allowed to stabilize before data are taken.

Towing at Sea

If a barge or other vessel is available for the test craft to tow, then at-sea towing trials can be performed. The procedure for these trials is the same as for the bollard pull tests except that speed will also need to be measured. The towing speed will be increased in steps until full power is reached or until the maximum safe towing speed (based on the size and character of the tow, the strength of the towing arrangements and prudent seamanship) is obtained. The tests must be discontinued **immediately** if the safe working load of any of the loaded components is reached.

If possible, two or more vessels of significantly different drag should be towed to better document the performance of the test vessel.

MEANS OF DETERMINING DATA

Shaft horsepower, towline pull, and speed are the principal data to be collected. Shaft horsepower requires the collection of data on shaft torque and shaft RPM. Towline pull force can be measured using a load cell in the towline. Speed for the at-sea trials will be determined from vessel positions at specific times.

Shaft thrust should also be recorded if instrumentation to measure the thrust is installed. This is rarely the case. Installing transducers to measure shaft thrust is not recommended because of the minimal value of the data obtained and the expense of the installation.

Propeller curves for the actual propellers installed should be obtained if available. These curves are useful in checking results.

PARAMETERS VARIED AND HELD CONSTANT

During the test, the shaft RPM will be set to a specific level and a reading of towline pull taken. In the at-sea towing trials, the power level must be maintained long enough to determine speed accurately. Wave height, wind speed, and current should be minimal as they will have a large effect on the results. The tests may be duplicated for different operating configurations if desired.

The following data are to be collected:

1. Shaft torque for each shaft at least once per second (see Instrumentation note 10)
2. Shaft RPM for each shaft at least once per second
3. Towline force once each second
4. Ship position updated at least once every fifteen seconds
5. Exact time of position readings
6. Draft and trim of the vessel
7. Operating configuration
8. Wave height and direction
9. Wind speed and direction
10. Current speed and direction
11. Water depth
12. Temperature and density of water in the trial area
13. Shaft thrust (if available)

INSTRUMENTATION REQUIRED

1. A shaft torsionmeter which can be interfaced with the computer data-gathering system.
2. A shaft RPM counter capable of interfacing with the computer

3. A load cell of adequate size to measure the maximum bollard pull. Read-out must be capable of interfacing with the computer.
4. LORAN-C receiver for position fixing
5. Real-time clock
6. Anemometer for wind speed and direction
7. Electronic depth sounder
8. Hydrometer for measuring water density
9. Thermometer for measuring water temperature
10. Computer data system for recording data. Hand recording of Items 6 through 9 is always acceptable. If a computer data system is not available, manual recording of all data may be employed recording the mentally deduced average value for each 15 second period.

DATA FORMS

Form 5A is to be used to record the data not stored on computer disks or tape.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

Shaft torque and SRPM data are to be processed together with appropriate constants to determine shaft horsepower. For the at-sea trials, the boat positions and time data will be used to compute average towing speed.

A curve will be drawn showing bollard pull versus shaft horsepower and versus SRPM. These curves will be annotated with the draft and trim of the vessel; water depth, density and temperature; wind speed and wave conditions and operating configuration.

If shaft thrust is available, a separate curve will be plotted of shaft thrust versus shaft horsepower.

Data from the at-sea trials will be plotted in the same way. Separate curves will be shown on the same plot if two or more vessels were towed. A plot of speed versus RPM while towing is also to be drawn.

DATA FORM 5A

TOWING CAPABILITY

VESSEL NAME ______________________ DATE ______________

RECORDER ______________________

LOCATION ______________________

DRAFT FORWARD ______________

AFT ______________

OPERATING CONFIGURATION ______________________

VESSEL TOWED NAME ______________________ TYPE ______________

LENGTH ______________ DISPLACEMENT ______________

WAVE HEIGHT ______________ WAVE DIRECTION ______________

CURRENT SPEED ______________ CURRENT DIRECTION ______________

RUN #	TIME	TAPE COUNTER	COURSE	SPEED	PORT SRPM	PORT HP	STBD SRPM	STBD HP	TOW LINE TENSION

WATER DEPTH ______________

TEMPERATURE WATER ______________

DENSITY OF WATER ______________

DATA DISKS/TAPE NUMBER ______________

TEST RUN NUMBERS ______________________

DATA FORM 5B

BOLLARD PULL

VESSEL NAME ______________________________ DATE ________________

RECORDER ________________________________

LOCATION ________________________________

DRAFT FWD ______________________ DRAFT AFT ______________________

WATER DEPTH _____________________ TEMP ________ DENSITY ________

		TAPE	PORT MAIN ENGINE		STBD MAIN ENGINE		TOWLINE
RUN #	TIME	COUNTER	SRPM	HP	SRPM	HP	TENSION

TEST NUMBER 6

TACTICAL DATA

OBJECTIVE

To determine turning circle parameters, acceleration, and stopping characteristics of the test vessel.

PROCEDURE

Turning Circle

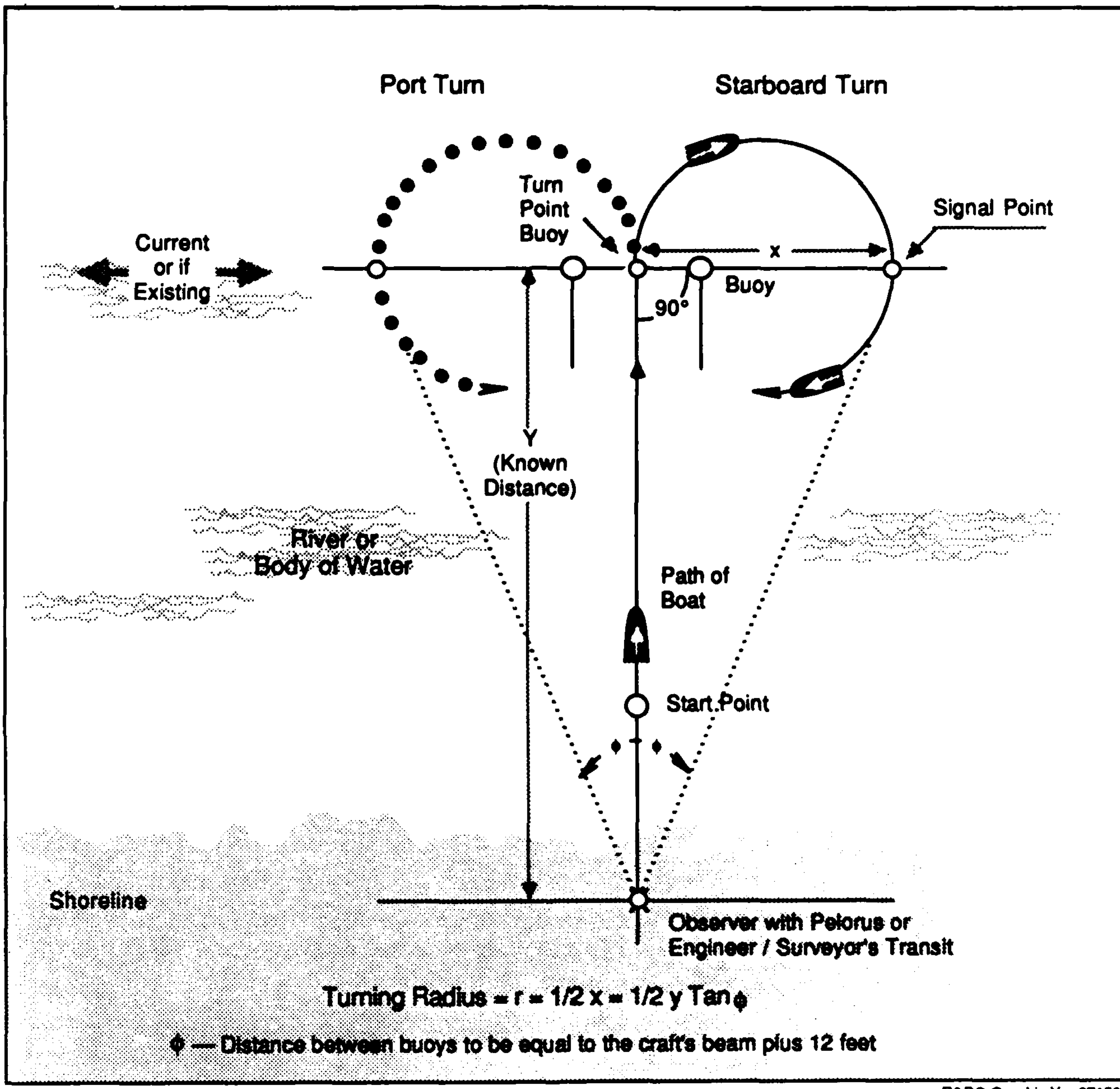
Turning circle data will be taken at three speeds ahead. These speeds are to correspond to approximately 1/3, 2/3, and maximum speed. If the test craft has two or more distinctive operating configurations, the test should be repeated for each.

At each of the three speeds, turns will be made both right and left at three rudder angles. These rudder angles are to correspond to 1/3, 2/3, and full rudder. All turns will begin with the ship on a straight course at stable speed. The course will continue until sufficient positional data points are available to accurately compute the speed. On signal, the rudder will be put over to the desired rudder angle and held there for the remainder of the turn. The turn will continue for 540 degrees or 1-1/2 times around.

If electronic position-indicating equipment is unavailable, or if its accuracy is insufficient, as is the case for small boats, an alternative procedure using buoys and an observer on shore may be used. A site is selected with adequate open area and minimum of current. The site should be opposite an on-shore or fixed anchorage observer position as shown in Figure 6. Two buoys are moored as indicated. The observer site is equipped with a pelorus or a transit. The distance "y" is measured and is sufficient to permit the vessel to develop full speed prior to reaching the turn point.

The vessel is positioned at the start point, is started, and is moved at the desired speed along the path indicated on Figure 6. Upon reaching the turn point buoy, the desired helm order is executed. The vessel continues in a circle until it has turned 180 degrees and reached the signal point. The observer notes and records the angle between the starting path and the signal point. To pinpoint time, a signal may be transmitted from the vessel to the observer at the instant the two turn buoys are aligned, indicating the 180 degree point.

The vessel is repositioned at the starting point and proceeds to accomplish the next speed and helm order.



R&DC Graphic Yng87150

FIGURE 6-1. Turning Radius Determination

More complicated optical tracking schemes can be devised using multiple observers and points of reference to gain the same sort of X-Y position information as the electronic systems, with obvious limitations in range and allowable weather conditions.

Acceleration and Stopping

The time and distance to accelerate from dead in the water to full speed ahead will be found in this test as well as the time to come to a stop from full ahead (crash stop) and the time to go from full ahead to full astern (crash reversal). In each of these trials, maximum power is to be used. Position information will again be used to determine the distances involved and the deviation from the base course when stopping and reversing. The rudder should be left amidships during these maneuvers.

MEANS OF DETERMINING DATA

The key parameters for the turning circles include: ship speed, ship position, shaft RPM, and rudder angle all measured against time. The parameters for acceleration and deceleration trials include ship speed and ship position measured against time. Ship heading is a secondary parameter for the turning circle trials.

Ship speed can be obtained from the ship's position so does not need to be collected separately. Accurate rudder angle and SRPM are important and transducers should be installed to measure these quantities. Ship heading is useful for analyzing the data and should be recorded if motion instrumentation is installed. If not, the time for passing each 90 degrees from the base course should be noted manually.

PARAMETERS VARIED AND HELD CONSTANT

The same water depth, wind, wave, and current conditions apply to these trials as apply to Test 3, speed versus power. Namely:

Water Depth $10\ HV/(L)^{1/2}$

where H = vessel draft
V = maximum speed
L = LBP

Wave Height	<	2 feet for WPB or larger, light chop for small boats
Wind Speed	<	15 Knots for WPB or larger, 10 Knots for small boats
Current Speed	<	1/4 knot

The parameters to be varied for each of the trials has already been described under PROCEDURE.

The following data is to be collected for the turning circle trials:

1. Ship position at least every fifteen seconds for ships, every five seconds for boats.
2. Exact time of each position
3. Shaft RPM
4. Rudder angle
5. Draft and trim of vessel
6. Operating configuration
7. Wave height and direction
8. Wind speed and direction
9. Current speed and direction
10. Water Depth
11. Temperature and density of water
12. Ship's heading or time of passing each 90 degrees
13. Roll angle, if motions package is available

Data for the acceleration and deceleration trials is the same except that rudder and roll angle information is not required.

INSTRUMENTATION REQUIRED

1. LORAN-C receiver, or microwave position finding equipment which can be interfaced with computer data-gathering system, OR a pelorus or engineers transit and several buoys.
2. Real-time clock
3. Shaft RPM counter
4. Rudder angle transducer
5. Anemometer for wind speed and direction
6. Electronic depth sounder
7. Thermometer and hydrometer for water temperature and density
8. Motion package (only if already installed)
9. Computer data-gathering system. No attempt should be made to conduct this test without suitable recording equipment.

DATA FORMS

Form 6A is to be used to record the data not stored on computer disks or tape.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

Turning circle data will be shown in the form of tables and plots of the following parameters:

1. Speed (approach and during turn)
2. Rudder angle
3. Approach RPM
4. Base course
5. Advance
6. Transfer
7. Tactical diameter
8. Turning circle diameter
9. Time at 360 degrees

Notation will be included of the other data collected.

See "Principles of Naval Architecture" for a complete description of each of the turning circle parameters, which will be obtained from the plots of position versus time. Generally some hand fairing of the data will be needed in order to get a smooth ship's track, and to enable the distances and diameters to be measured. The alternate procedure using the shore observer computes the turning circle diameter only using the formula shown in Figure 6.

Deceleration and acceleration data will be reported as curves of reach and speed versus time. Plots of the vessel's trackline will also be given for the deceleration trials. These plots will be annotated with the other data collected.

DATA FORM 6A

TACTICAL DATA

VESSEL NAME ______________________________ DATE ____________

RECORDER ______________________________

TIME START ________________________ LOCATION ________________

FINISH ________________________

DRAFT FORWARD ______________________

AFT ______________________

OPERATING CONFIGURATION ______________________________________

____

WAVE HEIGHT____________________ WAVE DIRECTION ______________

WIND SPEED ____________________ WIND DIRECTION ______________

CURRENT SPEED __________________ CURRENT DIRECTION ____________

WATER DEPTH ____

WATER TEMPERATURE ____

WATER DENSITY ____

RUN NUMBER _________ RUDDER ANGLE _________ SPEED __________

TIME	HEADING	
________	__________	BASE COURSE = BC
________	__________	BC ± 90
________	__________	BC ± 180
________	__________	BC ± 270
________	__________	BC ± 360
________	__________	BC ± 450
________	__________	BC ± 540

DATA DISKS/TAPE NUMBER ____

TEST NUMBER 7

DIRECTIONAL STABILITY

OBJECTIVE

To assess the vessel's ability to be steered on a straight course. This test evaluates the entire ship system, including the helmsman or coxswain, and can be used to identify problems such as yawing in following seas.

PROCEDURE

The test consists of having the helmsman hold as steady a course as he/she is able for 10 minutes. A landmark on shore makes the best heading reference, but a gyro or magnetic compass may be used. When conducting the test in calm water, any course may be chosen. If the seas are relatively calm, but a wind in excess of 10 kts is present, a course either directly into or with the wind should be chosen. If the seas are over 2-3 ft, multiple courses should be run as per Test Number 13 - Motion in Waves .

Repeat tests should be run with different helmsmen.

MEANS OF DETERMINING DATA

Some means must be provided for recording the activity of the the vessel's steering system. This may involve taking a signal from an existing rudder or drive angle indicator, or fitting such a device to the tiller, rudder post, wheel or outboards. The signal (preferably a voltage) should be recorded on an analog tape recorder. Alternatively, it may be used as an input to a Digital Data Acquisition System.

PARAMETERS VARIED AND HELD CONSTANT

The helmsman, to the best of his/her ability, attempts to hold the course of the vessel constant. The throttle settings are left unchanged for the duration of the test, as are all other relevant operating characteristics. Tests may be run at different speeds; suggested speeds are the vessel's Economical Cruise speed, Maximum Speed, and Minimum Speed.

The following data is to be collected:

1. Draft and Trim of the vessel
2. Operational Configuration
3. Wave height and direction
4. Wind Speed and direction
5. Current speed and direction
6. Water depth
7. Experience Level of Helmsman

INSTRUMENTATION REQUIRED

1. Anemometer for wind speed and direction
2. Depth sounder
3. Rudder angle indicator or equivalent
4. Analog tape recorder or digital Data Acquisition System
5. Signal Analyzer
6. Hand recording is suitable for all data other than rudder angle.

DATA FORMS

Data form 7a is to be used to record data on conditions of the test. Data form 7b may to be used to reduce rudder angle data from sources not recorded on tape, or if a signal analyzer or program is not available.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

The signals of the rudder angle transducers shall be reduced to engineering units and and plotted as an amplitude histogram with rudder angle as the x-axis. This is most easily done by using a signal analyzer. The y-axis values should be non-dimensionalized by using the number of observations, or the total time of the test, as appropriate. If a digital Data Acquisition System is used to record the data, then the raw data must be processed using the appropriate software to yield a histogram.

If the data must be reduced by hand, a hard copy of the time history should be obtained. This may be a strip chart or oscillograph trace, or a printout of the digitized data. The range of the rudder angle output should be divided into at least 20 (preferably many more) equal bands. For strip chart data, the total time the trace is within each band is found. For tabular data, giving the signal at equally spaced time intervals, the number of times the signal is within each band is tabulated. The results are then divided by the total time of the test or the total number of observations to non-dimensionalize the plot. A bar graph, with the bands of helm activity as the ordinate and the non-dimensionalized occurrences as the abscissa, is then constructed. Figure 7-1 shows examples of data reduction by hand.

The Mean, Standard Deviation, and Skewness should be computed for the non-dimensionalized distribution

INTERPRETATION OF DATA

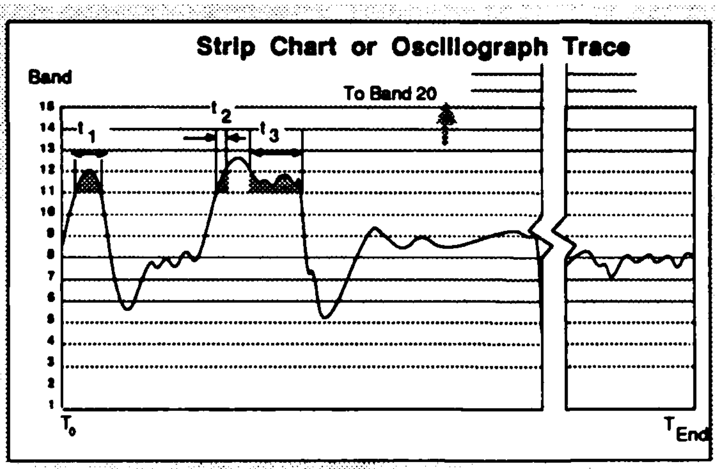
Since this test is new, and is not referenced in the standard Naval Architecture texts, a few notes on it's interpretation are in order.

Tabular Output

Time	Rudder Angle (deg.)	
0:00:00	0.08	*(Band 10)*
	0.11	*(Band 10)*
	0.27	*(Band 11)*
0:00:10	0.34	*(Band 12)*
	0.24	*(Band 11)*
	0.22	*(Band 11)*
	0.36	*(Band 12)*
etc.	etc.	

Band	Range (deg.)	Occurrences	Non-dimensional
1			
↓			
10	0 — .15	II . . . n_{10}	n_{10} /total
11	.15 — .30	III . . . n_{11}	n_{11} /total
12	.30 — .45	II . . . n_{12}	n_{12} /total
↓			
20			

Total = $\Sigma n_1 + n_2 + n_3 + n_4 \ldots n_{20}$



Band	Range (deg.)	Time	Non-dimensional
1			
↓			
11	.15 — .30	$t_1 + t_2 + t_3 \ldots t_n$	$\sum_{i=1}^{n} t_i$ /Total
↓			
20			

Total = $T_{End} - T_0$

FIGURE 7-1. Data Reduction by Hand

If the vessel is directionally stable, the seas flat, the winds calm, and their are no asymmetries in the hull, rudder, steering system, etc., the histogram will show a relatively narrow normal distribution centered on zero. If there are any influences on the vessel which are non-symmetrical, such as misaligned dual rudders, wind or waves from the beam or quarter, then even a stable ship will display a shift in the peak of the distribution to the right or left of center, along with some spreading away from the mean (an increase in the standard deviation). As a ship becomes less stable, the distribution spreads, until finally an un-stable vessel will show a double-peaked histogram.

Typical histograms for stable and unstable vessels are shown in figure 7-2. A vessel with neutral stability will exhibit a curve somewhere between these extremes. If a vessel's stability is suspect, a spiral test is strongly recommended to provide additional information.

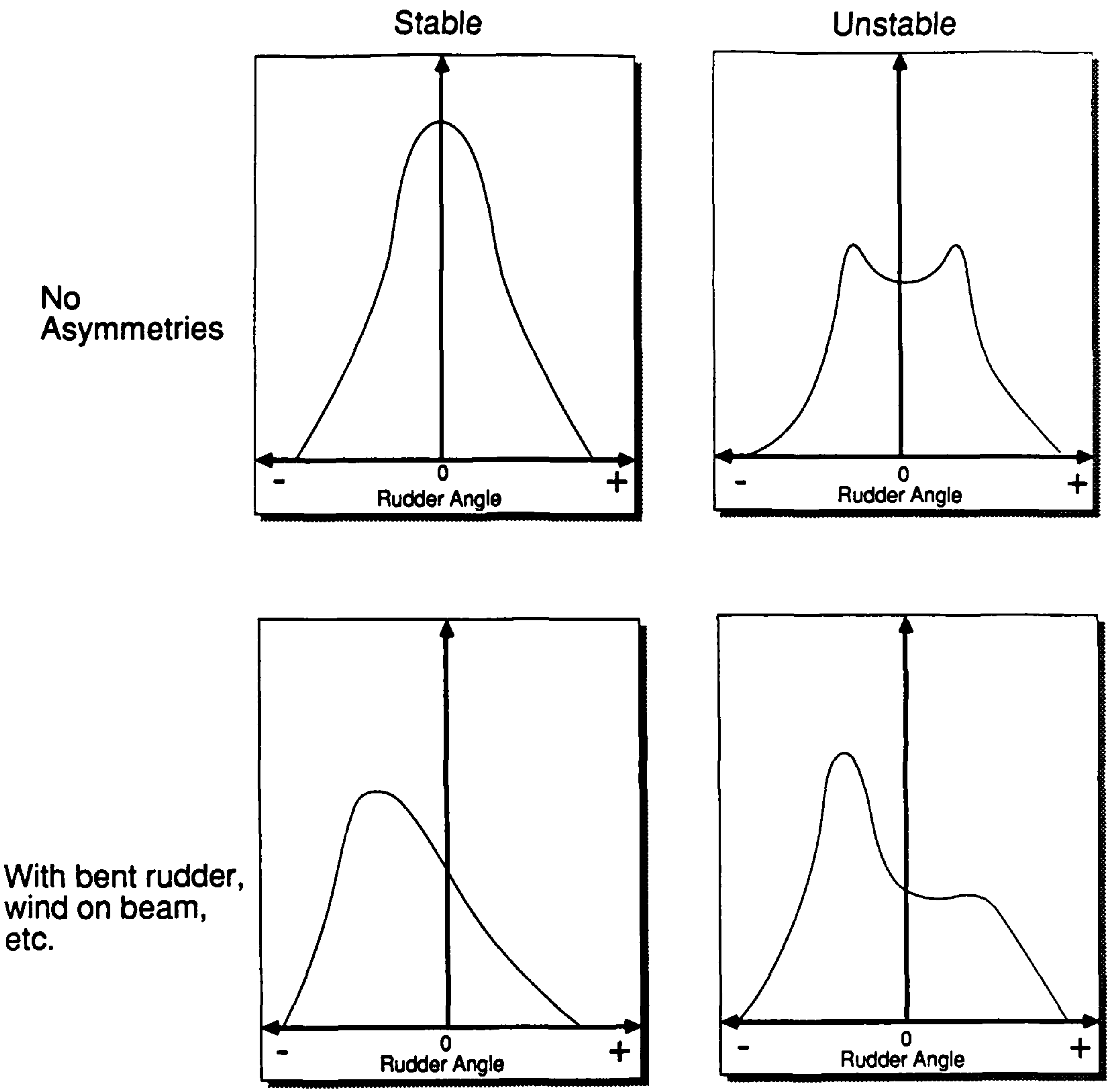

Stable
Unstable
No Asymmetries
With bent rudder, wind on beam, etc.
0
Rudder Angle
-
+

FIGURE 7-2

DATA FORM 7a

DIRECTIONAL STABILITY (RUDDER ANGLE HISTOGRAM)

VESSEL NAME ______________________ DATE ____________

RECORDER ______________________

LOCATION ______________________ WATER DEPTH ________

TIME START ______________________ FINISH ____________

OPERATING CONFIGURATION ______________________

WAVE HEIGHT ________________ WAVE DIRECTION ____________

WIND SPEED ________________ WIND DIRECTION ____________

DRAFT FWD ________________ AFT ____________

RUN # __________ SPEED __________ VESSEL'S HEADING __________

HELMSMAN & EXPERIENCE ______________________

TIME START ____________ FINISH ____________

TAPE COUNT START ____________ FINISH ____________

RUN # __________ SPEED __________ VESSEL'S HEADING __________

HELMSMAN & EXPERIENCE ______________________

TIME START ____________ FINISH ____________

TAPE COUNT START ____________ FINISH ____________

RUN # __________ SPEED __________ VESSEL'S HEADING __________

HELMSMAN & EXPERIENCE ______________________

TIME START ____________ FINISH ____________

TAPE COUNT START ____________ FINISH ____________

DATA FORM 7b

DIRECTIONAL STABILITY (RUDDER ANGLE HISTOGRAM)

Band (#)	Range (volts)	Range (deg)	Occurrences or Time in band (# or sec)	Non-dimensional

Total Time or Occurrences = ____________________

TEST NUMBER 8

MANEUVERABILITY - SPIRAL TEST

OBJECTIVE

To determine the vessel's maneuverability using the Dieudonne Spiral Maneuver.

PROCEDURE

For conventional displacement craft speed has little effect on directional stability as measured by this test. Since unconventional craft are to be tested, it is recommended that at least two ahead speeds and one astern speed be tested. These speeds should be approximately 1/3 and 2/3 speed ahead and half speed astern. If they are known, the boat's speed most unfavorable to directional stability should be substituted.

If two or more significantly different operating configurations are possible each should be tested. The test is very sensitive to wave and weather conditions. The spiral test is intended to provide a measure of the directional stability of the ship. If the vessel is unstable, it usually possesses two stable yaw rates for the same rudder angle. Significant wind or sea loads can cause the yaw rate to switch from one of these rates to the other. Winds, therefore, must be less than five knots and seas less than one foot.

With the vessel in the specified operating configuration and proceeding ahead at the designated speed on a steady course, the rudder is moved to 15 degrees to starboard and held until the turning rate becomes steady. The rudder is then moved to each of the following successive settings and held until a steady turning rate is obtained, 10 deg. R, 5 deg. R, 3 deg. R, 1 deg. R, 0 deg., 1 deg. L, 3 deg. L, 5 deg. L, 10 deg. L, 15 deg. L, 10 L, 5 deg. L, 3 deg. L, 1 deg. L, 0 deg., 1 deg. R, 3 deg. R, 5 deg. R, 10 deg. R, 15 deg. R.

If any of the rudder angles is overshot, it is essential to leave the rudder at that angle and not return it to the value listed.

MEANS OF DETERMINING DATA

Rudder angle and yaw rate are the key parameters in this test. The rudder angle can be set by the helmsman using installed indicators if these are known to be reasonably accurate. However, the actual rudder angle should be measured with a transducer installed on the rudder shaft. Yaw rate should be measured with a motion transducer. This is preferable to reading gyro angles at fixed time increments and provides an excellent indication of when the yaw rate has settled to a steady value.

Boat speed is not critical and can be approximated by setting shaft RPM to a value known to produce the desired speed. If an accurate means of setting the speed is not known, then the boat's position should be plotted and the speed calculated on-scene until a reasonably close approximation to the required speed is obtained.

PARAMETERS VARIED AND HELD CONSTANT

As mentioned earlier, wind and weather conditions are particularly critical for this test. Required values are:

Wind Speed	<	5 knots
Wave Height	<	1 foot

In addition, water current should be less than one knot. The parameters to be varied have been described under PROCEDURE.

The following data is to be collected:

1. Boat speed and corresponding RPM
2. Rudder angle
3. Yaw rate
4. Wind velocity and direction
5. Boat's base course
6. Water depth
7. Wave height and direction
8. Draft and trim of vessel
9. Operating configuration
10. Current speed and direction

INSTRUMENTATION REQUIRED

1. LORAN-C receiver may be required if accurate speed versus RPM data is not available.
2. Rudder angle transducer capable of interfacing with computer
3. Yaw rate transducer (motion package) capable of interfacing with computer.
4. Anemometer for wind speed and direction
5. Depth sounder
6. Computer data-gathering system

DATA FORMS

Form 8A is to be used to record the data not stored on computer disks or tape.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

Yaw rate will be plotted against rudder angle and annotated with the other parameters obtained. This plot gives a direct indication of the stability or instability of the vessel.

DATA FORM 8A

MANEUVERABILITY - SPIRAL TEST

VESSEL NAME ______________________________ DATE ____________

RECORDER ______________________________

BASE COURSE ____________ SPEED ____________ RPM ____________

WAVE HEIGHT ____________ WAVE DIRECTION ______________

WIND SPEED ____________ WIND DIRECTION ______________

CURRENT SPEED __________ CURRENT DIRECTION ____________

WATER DEPTH ______________________________

DRAFT FORWARD ________________

AFT ________________

OPERATING CONFIGURATION ______________________________

____

Rudder Angle (Deg.)	Start Time	Tape Counter	Rudder Angle (Deg.)	Start Time	Tape Counter
15R			15L		
10R			10L		
5R			5L		
3R			3L		
1R			1L		
0			0		
1L			1R		
3L			3R		
5L			5R		
10L			10R		
15L			15R		

DATA DISKS/TAPE NUMBER ______________________________

TEST RUN NUMBERS ______________________________

TEST NUMBER 9

MANEUVERABILITY - ZIGZAG TEST

OBJECTIVE

To determine the vessel's maneuverability using the zigzag maneuver and to determine the limit of low speed maneuverability.

PROCEDURE

The results of this test are dependent on the vessel speed used during the test. As a result, the test should be conducted at different speeds and using different operating configurations. Three speeds are recommended. These are idle speed, half ahead, and full ahead. Each significantly different operating condition should be tested in the zigzag maneuver. Low speed maneuverability need only be tested in the operating configuration most likely to be used for low speed maneuvering. If the vessel cannot operate at speeds less than 6 knots, the low speed maneuvering tests cannot be performed.

With the vessel in the specified operating configuration and proceeding ahead into the wind at the specified speed, move the rudder at the maximum rate and perform the following maneuvers:

Rapidly move the rudder from amidships to 20 deg. R - hold until vessel's heading is 20 degrees to the right of the original course.

Rapidly move the rudder from 20 deg. R to 20 deg. L - hold until vessel's heading is 20 degrees to the left of the original course.

Rapidly move the rudder from 20 deg. L to 20 deg. R - hold until vessel's heading is 20 degrees to the right of the original course.

Rapidly move the rudder from 20 deg. R to 20 deg. L - hold until original heading is restored. Steady on original course. Additional zigzags can be made before returning to base course if desired.

In the low speed maneuverability test, the following procedures will be used:

With the vessel in the specified operating configuration and proceeding into the wind on a steady course at six knots ahead, conduct the following maneuvers:

Lay the rudder to 10 deg. R and hold for 30 seconds.

Move the rudder to 10 deg. L and hold for 30 seconds.

Move the rudder to 0 deg. and hold for 30 seconds.

Return to the base course and adjust the speed to six knots with the rudder at 0 deg.

Lay the rudder to 35 deg. R and hold for 30 seconds.

Move the rudder to 35 deg. L and hold for 30 seconds.

Move the rudder to 0 deg. and hold for 30 seconds.

Return to base course and adjust to the next speed.

Repeat the maneuver with the speed decreased at one-knot intervals until the speed at which the vessel does not respond to the helm is determined.

Wind speed should be below 15 knots and wave height should be below three feet for WPB and larger vessels during these trials. 10 knots and 2 feet are the limits for small boats, and calmer seas are preferred.

MEANS OF DETERMINING DATA

No critical measurements are required for the low speed maneuverability trials. For the zigzag maneuver, the rudder angle, yaw angle, and vessel position are required. Ship speed is not critical and can be approximated using SRPM.

PARAMETERS VARIED AND HELD CONSTANT

Wind speed and wave height limits were given earlier. Current should be less than one-half knot. Water depth should be as specified for speed/power trials.

The following data is to be collected for the zigzag maneuver:

1. Base course
2. Time of rudder shifts
3. Rudder angle
4. Yaw angle
5. SRPM while on base course initially
6. Wind velocity and direction
7. Wave height and direction
8. Current speed and direction
9. Water depth
10. Draft and trim
11. Boat's position
12. Operating configuration

These same data will be collected for the low speed maneuverability test. Rudder angle and yaw angle measurements for that test are not critical and can be eliminated if desired.

INSTRUMENTATION REQUIRED

1. Rudder angle transducer capable of interfacing with a computer
2. Yaw angle transducer (motion package) capable of interfacing with a computer
3. Anemometer for wind speed and direction
4. Depth sounder
5. LORAN-C receiver capable of interfacing with a computer
6. Real-time clock

DATA FORMS

Form 9A is to be used to record the data for the zigzag maneuver and Forms 9A and 9B will be used for the low speed maneuverability trials. Other data will be stored on computer disks or tape.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

For the zigzag maneuver, the data will be presented as plots of rudder angle, yaw angle, and position all against time. These plots will be annotated with the other parameters measured.

The following parameters measured from the plots will be presented in tabular form:

(a) Time from first execute to second execute
(b) Period of the zigzags
(c) Overshoot yaw angle
(d) Overshoot width of path

For the low speed maneuverability test, the maximum departures of yaw from the base course will be reported in tabular form for each speed-rudder angle combination. Also reported will be the speed at which the ship could no longer effectively maneuver.

DATA FORM 9A

MANEUVERABILITY - ZIGZAG TEST

VESSEL NAME ______________________________ DATE ____________

RECORDER ______________________________

TIME START ______________ LOCATION ______________________

OPERATING CONFIGURATION ______________________________________

BASE COURSE ______________ SRPM __________ SPEED __________

DRAFT FORWARD ______________________________

AFT ______________________________

WATER DEPTH ____

WAVE HEIGHT __________________ WAVE DIRECTION ________________

WIND SPEED ___________________ WIND DIRECTION ________________

CURRENT SPEED ________________ CURRENT DIRECTION _____________

TIME OF FIRST EXECUTE ________ ___ LORAN POSITION LAT _______

TIME OF SECOND EXECUTE _______ LONG _______

TIME END OF TEST _____________ ___ LORAN POSITION LAT _______

LONG _______

NOTE: MAINTAIN BASE COURSE ± 2 DEGREES FOR AT LEAST 30 SECONDS BEFORE FIRST EXECUTE.

USE 20 DEGREES RUDDER AND MAINTAIN UNTIL COURSE IS BASE COURSE ± 20 DEGREES.

SET YAW GYRO TO ZERO WHILE ON BASE COURSE INITIALLY.

DATA DISKS/TAPE NUMBER ______________________________________

TEST RUN NUMBERS ____

DATA FORM 9B

LOW SPEED MANEUVERABILITY

VESSEL NAME ______________________________ DATE ____________

RECORDER ______________________________

RUDDER ANGLE/SPEED CHECK-OFF LIST

HELM ORDER	6 KNOTS	5 KNOTS	4 KNOTS	3 KNOTS	2 KNOTS	1 KNOT
RIGHT HALF	_____	_____	_____	_____	_____	_____
LEFT HALF	_____	_____	_____	_____	_____	_____
CENTER	_____	_____	_____	_____	_____	_____
RIGHT FULL	_____	_____	_____	_____	_____	_____
LEFT FULL	_____	_____	_____	_____	_____	_____
CENTER	_____	_____	_____	_____	_____	_____

TEST NUMBER 10

SLOW SPEED AGILITY

OBJECTIVE

To assess a vessel's ability to maneuver at slow speed in tight quarters, such as encountered in docking, towing, and man-overboard situations.

PROCEDURE

Using small buoys, a rectangular box, open at one end, 1 1/2 boat lengths wide by 2 boat lengths long is laid out in a sheltered area away from strong winds, waves and currents. A qualified coxswain enters the box on one of the short ends so that the vessel under test is completely within the box, then by casting about (using any combination of helm and throttle settings desired), performs a 180 degree turn and exits the box, without having touched the sides of the enclosure. This maneuver should be performed several times, with several coxswains, and a 41 ft UTB , a 44 ft MLB or a RHI should be available for comparison.

This test should not be considered valid unless at least 3 coxswains perform the maneuver 5 times in each of two vessels, the test vessel and a reference vessel.

MEANS OF DETERMINING DATA

The success or failure of the vessel to perform the tests is the primary data to be collected. Secondary data shall include the time from the bow's entrance into the box until the stern's exit, the engine RPM and/or throttle setting used at the start of the test, the number of helm and propeller direction changes needed to perform the maneuver, and the helmsman's evaluation as recorded on Data Form 10.

PARAMETERS VARIED AND HELD CONSTANT

The operating condition of the vessel shall be typical for it's designed mission. The Helmsman should be a qualified small boat Coxswain experienced in UTB, MLB, TANB, RHI or other small boat operations. Use of several different Coxswains with different levels and types of experience is strongly recommended. Wave height, wind speed and current should be minimal as they will have a large effect on the results.

The following data is to be taken:

1. Success or failure of each maneuver
2. Time to complete the maneuver
3. Engine RPM or throttle setting upon entering the course
4. Number of Back and Fill attempts needed to complete the maneuver

5. Draft and Trim of the vessel
6. Operational Configuration
7. Wave height and direction
8. Wind Speed and direction
9. Current speed and direction
10. Water depth
11. Exact dimensions of the test enclosure

EQUIPMENT REQUIRED

1. At least 7 marker buoys, preferably with a staff such as a man-overboard buoy.
2. Stopwatch
3. Anemometer for wind speed and direction
4. Depth sounder
5. Polypropylene line marked at one-foot intervals or other means to accurately position the buoys
6. Hand recording is suitable for all data

DATA FORMS

Form 10 is used to record the data, and Questionnaire 10 is used to record the Coxswain's impressions

PHOTO DOCUMENTATION

A video record of the maneuver is highly desirable. Still photos at regular intervals may also be taken.

ANALYSIS OF DATA

The number of successful maneuvers shall be divided by the number of attempts to determine the success ratio. The time to complete the maneuver should be presented as an average, and if there appears to be a "learning curve" it shall be presented as a function of the number of attempts. The results from the questionnaires should be tabulated and presented, along with any significant comments on Data Form 10.

DATA FORM 10
SLOW SPEED AGILITY

VESSEL NAME ______________________ DATE ______________

RECORDER ______________________________

LOCATION ______________________ WATER DEPTH ________

TIME START ___________________________ FINISH ____________

OPERATING CONFIGURATION ____________________________________

DRAFT FWD ____________________ AFT ____________________

WAVE HEIGHT ____________ WAVE DIRECTION ____________

WIND SPEED ____________ WIND DIRECTION ____________

RUN NUMBER							
	___	___	___	___	___	___	___
COXSWAIN	___	___	___	___	___	___	___
BOAT	___	___	___	___	___	___	___
SUCCESSFUL ?	___	___	___	___	___	___	___
TIME (SEC)	___	___	___	___	___	___	___
# OF BACK/FILLS	___	___	___	___	___	___	___

Draw a sketch showing the dimensions of the test course. Note how the buoys were located (i.e., using a transit, measuring line, etc).

QUESTIONNAIRE 10 - SLOW SPEED AGILITY

VESSEL NAME ____

YOUR NAME ______________________________ DATE ___________

TIME IN SMALL BOATS ______________________

This questionnaire covers some of the aspects of slow speed boat handling that are difficult to measure. Answer the questions which you feel are within your experience. Check **Not Observed** if you do not feel qualified to answer the question or if it does not apply to the boat you tested. If there are any additional comments you would like to make regarding slow speed handling, please include them in the Remarks section.

1. Overall, how do you feel the slow speed handling of this boat compares to a 44 ft MLB ?

Much better	____	Worse	____
Better	____	Much worse	____
About the same	____	Not Observed	____

2. Overall, how do you feel the slow speed handling of this boat compares to a 41 ft UTB ?

Much better	____	Worse	____
Better	____	Much worse	____
About the same	____	Not Observed	____

3. Overall, how do you feel the slow speed handling of this boat compares to a RHI ?

Much better	____	Worse	____
Better	____	Much worse	____
About the same	____	Not Observed	____

4. How do you rate the overall slow speed handling of this boat?

Excellent	____	Poor	____
Good	____	Terrible	____
Only fair	____		

5. How would you rate the ease of use of the engine controls?

Excellent	____	Poor	____
Good	____	Terrible	____
Only fair	____		

6. How would you rate ease of use and power of the helm?

Excellent	____	Poor	____
Good	____	Terrible	____
Only fair	____		

QUESTIONNAIRE 10 - SLOW SPEED AGILITY (cont'd)

7. Can the Coxswain see the side of the boat from his position?

Yes ____ No ____

Comments ________________________________

8. Can the Coxswain communicate with the crew from his position?

Yes ____ No ____

Comments ________________________________

9. Without yelling ?

Yes ____ No ____

Comments ________________________________

10. Can the Coxswain easily reach the controls?

Yes ____ No ____

Comments ________________________________

11. Can the Coxswain easily read the gauges without distraction or interference from other objects ?

Yes ____ No ____

Comments ________________________________

12. How would you rate the overall arrangement of the Coxswain's position for slow speed handling?

Excellent	____	Poor	____
Good	____	Terrible	____
Only fair	____		

13. What is the boat's behavior when backing with the helm centered and both engines reversed at the same speed?

Veers sharply to Port	____	Drifts to Stbd	____
Drifts slowly to Port	____	Veers to Stbd	____
Backs relatively straight	____	Not Observed	____

14. Does the boat back easier in one direction than the other?

Much easier to back to Port	____	Easier to Stbd	____
Easier to back to Port	____	Much easier to Stbd	____
About the same	____	Not Observed	____

QUESTIONNAIRE 10 - SLOW SPEED AGILITY (cont'd)

15. How would you rate the rudder effectiveness in reverse?

Excellent	____	Poor	____
Good	____	Terrible	____
Only fair	____		

16. How would you rate the boat's ability to "twist" with the throttles split?

Excellent	____	Poor	____
Good	____	Terrible	____
Only fair	____		

17. Does the boat twist easier in one direction than the other ?

Much easier to twist to Port	____	Easier to Stbd	____
Easier to twist to Port	____	Much easier to Stbd	____
About the same	____	Not Observed	____

18. Remarks. Comment on any factors concerning slow speed handling which were not covered above.

TEST NUMBER 11

SELF-RIGHTING ABILITY

OBJECTIVE

To determine whether or not a vessel can, without outside influence, right itself from a 180 degree capsize, and to assess the time such a righting will take, the damage done the vessel in a capsize and righting, and the possible hazards to it's crew.

The Overturning/Righting Moment curve at large angles of heel may also be verified using this test procedure.

PROCEDURE

The subject vessel is loaded as nearly as possible to it's operational condition. Outfitting on a vessel under construction should be very nearly complete, less electrical and electronic equipment which cannot withstand immersion. The vessel's doors and hatches should be secured as they would normally be in heavy weather and/or breaking surf conditions. Two crane slings, preferably wide fabric webbing, with a safe working load equivalent to the displacement of the vessel are attached to the gunwale of the vessel and lead under the keel to emerge opposite their attachment point. If a remote quick release can be arranged, at the attachment point of either the slings to the boat, or of the crane hook to the slings, this would diminish any effect of the crane wire or the slings on the boat's ability to right. The boat should be moored with a minimum of restraint to roll, as if for an inclining, and there should be at least one boat length clearance in all directions from any fixed or floating obstruction. The test director must make allowances for the vessel rolling in either direction once the slings have been released.

If there are any protective devices fitted to minimize damage in a capsize, such as engine or radar scanner cutoffs, they should be operating, along with the systems they protect.

Tension is slowly taken up on the crane until the vessel is inverted (175 degrees minimum). When the Test Director is certain that all is ready, the tension is released suddenly, either with a remote release or by releasing the brake on the crane. A weight on the crane wire may cut down on possible backlash of the winch drum.

MEANS OF DETERMINING DATA

The roll angle versus time is the principal data to be collected during the test. The roll angle should be measured using: 1) a transducer rigidly attached to the boat's structure and capable of recording 360 degrees of roll, and 2) by using a pendulum type indicator on the superstructure, transom, or stem of the vessel

large and legible enough to be read and photographed from a reasonable distance. Some method of synchronizing all observations should be employed.

The crane load versus roll angle can be used to compute the righting moment at the extreme roll attitudes seen during the test, and can be measured using the cranes own load indicator, or by using a load cell between the crane hook and the slings.

PARAMETERS VARIED AND HELD CONSTANT

The Vessel's inertial properties (Displacement, Center of Gravity, Metacentric Height, Free Surface and Roll Gyradius) should be held constant during repeated tests, and should adhere as closely as possible to the vessel's actual operational condition. The buoyancy, drag, and watertight integrity of all hull and topsides structures should also be preserved, and should also reflect actual operating conditions. For example, masts must be fitted, and structures of similar weight, profile and buoyancy to the various radomes and antennas that would normally be fitted. In between repeat tests, the vessel should be boarded and checked for damage. Any water shipped should be measured as it is removed, and note made of any spilled fluids, etc.

Water depth is immaterial, other than it should be at least equal to 1 1/2 times the height of the highest point on the vessel. Wind, wave and current conditions should be as calm as possible.

The following data is to be collected:

1. Roll angle versus time
2. Crane load versus time (optional)
3. Water Depth
4. Vessel draft and trim, before and after test
5. Water shipped and damage suffered

INSTRUMENTATION REQUIRED

1. Roll transducer capable of measuring 360 degrees. Ideally this would be a vertical gyro, but a dampened pendulum attached to a rotary encoder (optical, slide wire, etc) or a vertical accelerometer may be used instead.
2. Visual reading pendulum mounted on superstructure.
3. Depth sounder
4. Time code generator (optionally 2, with one outputing to photo or video equipment)
5. Recording equipment for roll and time code (analog)
6. Lines plans and hydrostatics curves

DATA FORMS

Data form 11a is to be used to record data on conditions of the test. Data form 11b is to be used to tabulate roll angle and crane load versus time from sources not recorded on tape.

PHOTO DOCUMENTATION

Data is also to be recorded photographically. At a safe distance directly astern of the vessel high speed still photography (interval motor drive), video and/or motion picture equipment (in that order of desirability) should be setup to record the vessel's righting motions. The visual indicating pendulum should be visible, and ideally time information should be included in the image in some manner.

ANALYSIS OF DATA

The signals of the roll transducers shall be reduced to engineering units and plotted as a function of time. The first derivative of the roll angle with respect to time shall also be computed and plotted. The time to right from 180 degrees to zero degrees roll shall be reported, along with the water shipped and damage sustained.

The crane load data must be converted to overturning moments by analyzing the still pictures and the lines plan to assess the moment arm through which the overturning force was acting. In this way, a righting moment versus roll angle curve can be computed, since overturning moments equal righting moments in the static condition of equilibrium. Corrections must be made for the weight of crane wire and boat attachment tackle.

DATA FORM 11a
SELF RIGHTING ABILITY

VESSEL NAME ______________________________ DATE ______________

RECORDER ______________________________

LOCATION ______________________________ WATER DEPTH ________

TIME START ______________________________ FINISH ____________

OPERATING CONFIGURATION ______________________________________

WAVE HEIGHT ____________________ WAVE DIRECTION _____________

WIND SPEED ____________________ WIND DIRECTION _____________

BEFORE TEST

DRAFT FWD ____________________ AFT ________________________

AFTER TEST

DRAFT FWD ____________________ AFT ________________________

WATER TAKEN ABOARD ____

____

DAMAGE ____

____

____

DATA STORED ON TAPE: ________________________

TAPE COUNT START ______________ TAPE COUNT FINISH ___________

DIGITIZED DATA ON DISK __________ FILE NAME _________________

DATA FORM 11b
SELF RIGHTING ABILITY

OVERTURNING MOMENTS (OPTIONAL)

TIME (SEC)	ROLL ANGLE (DEG)	CRANE LOAD (POUNDS)	ESTIMATED ARM(FT)	MOMENT (FT-LBS)

TEST NUMBER 12

MOMENT TO HEEL AND TRIM

OBJECTIVE

To determine the effect of moving a fixed weight already on board the vessel in the athwartship direction. Also to be determined is the radius of gyration about the fore and aft axes of the vessel.

PROCEDURE

The moments to heel and trim the vessel are available from the curves of form. However, the center of gravity assumed for the curves of form may be significantly different from the true center of gravity. The actual metacentric height will be confirmed by inclining the vessel through a small angle by moving fixed weight already on board. The procedures for a standard inclining experiment will be followed except that the inventory on board at the time of the experiment will be considered the in-service inventory and no additions or subtractions will be made. Tanks should be either entirely empty or pressed up. The actual level of each tank will be measured before the experiment.

The vessel will also be sallied in the athrwartships directions in order to determine the roll period. This will be accomplished by adding and quickly removing a weight from the vessel.

Weather for these tests must be excellent. They will be accomplished near a dock, preferably at slack tide with minimal wind or current effects. Waves are to be less than six inches.

MEANS OF DETERMINING DATA

In the inclining experiment, a known weight is moved through a precise distance and the resulting angle of heel or trim is precisely measured. The conventional method for measuring the angle is with a long pendulum.

A motion package capable of accurately ($\pm$ 1/4 degrees) measuring pitch and roll angles is required for the radius of gyration experiments. A weight will be added to the hull and removed to induce a pure roll motion and the roll decay curve will be recorded.

PARAMETERS VARIED AND HELD CONSTANT

Water depth is not critical for this experiment but should be at least ten feet greater than the draft of the vessel if possible.

Wave and weather conditions should be nearly dead calm. Namely:

Wind speed	< 5 knots
No current	
Wave	< 6 inches

If possible, the vessel should be headed into the wind for the trials.

The following data is to be collected for the inclining experiment:

1. Known weight
2. Distance weight is moved
3. Heel or trim angle (± 1 minute of arc)
4. Initial draft and trim
5. Water temperature and density
6. Wind speed and direction
7. Wave height
8. Tank soundings
9. Deck plans
10. Sounding tables
11. Righting moment curves for vessel
12. Water depth

For the radius of gyration test, the following is required:

1. Continuous roll or pitch angles (± 1/4 degrees)
2. Initial draft and trim
3. Tank soundings
4. Water depth

INSTRUMENTATION REQUIRED

1. Large pendulum
2. Crane and a large weight; weight size will depend on the vessel tested. An angle of approximately 2 degrees is required.
3. Motion package
4. Computer or tape data collection system
5. Thermometer and hydrometer
6. Sounding tapes
7. Depth sounder

DATA FORMS

Data Forms 12A and 12B will be used to record data from these experiments. Other data will be recorded on magnetic tape or computer disks.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

The metacentric (GM) height will be reported together with tank soundings, deck plans, and sounding tables for the tanks. No attempt will be made to reduce the data to determine the hull CG because the GM value for heel is more appropriate to the study of vessel motions and stability. The resulting data will be compared to the vessel's righting moment curve if it is available. The moment to trim one foot will also be reported from the curves of the form.

The radius gyration can be determined from the formula:

$$\text{Period} = \frac{1.1080 \times K}{(GM)^{1/2}}$$

where K is the radius of gyration
Period is the measured roll period
GM is the metacentric height computed by

$$GM = \frac{w \times d}{W \times \tan \theta} \qquad \text{From the inclining experiment}$$

w = weight of object moved (known weight)
d = distance moved
W = weight of the vessel
θ = the heel or trim angle measured

Radius of gyration and motion decay curves will be reported for roll motions.

REFERENCES

For further discussion of the inclining experiment, see the following references:

U.S. Army Test and Evaluation Command Test Operations Procedure, "Waterways Equipment - Boat, Barge, Motor". NTIS Accession #AD-759772.

United States Coast Guard Navigation and Vessel Inspection Circular No. 15-81, "Guidelines for Conducting Stability Tests".

"Principles of Naval Architecture", SNAME, 1967, pp 112-116.

DATA FORM 12A

INCLINING EXPERIMENT

PRE-TEST PREPARATIONS

VESSEL ____________________________________ DATE ____________________

RECORDER ____________________________ LOCATION ________________________

START TIME _______________________ FINISH TIME _________________________

DRAFTS START FINISH

STBD FWD _______________ _______________ READ TO NEAREST 1/4 INCH

PORT FWD _______________ _______________

STBD AFT _______________ _______________

PORT AFT _______________ _______________

WATER DEPTH ___________ RELATIVE WIND SPEED AND DIRECTION ___________

WATER TEMPERATURE __________________ WATER DENSITY ____________________

CHECK LIST

HAVE TANK LEVELS BEEN ADJUSTED ? ____ PERSONNEL BRIEFED ? ___

VALVES SECURED TO PREVENT TRANSFER OF LIQUIDS ? ____

SWINGING WEIGHTS SECURED ? ____ GANGWAY STOWED ? ______

LINES SLACKED ? ___

DATA FORM 12A

INCLINING EXPERIMENT

PAGE 2

VESSEL NAME ______________________________ DATE ________________

TRIAL NUMBER	1 INITIAL POSITION	2 MAX PORT	3 MAX STBD
DISTANCE TO CENTERLINE			
WEIGHT 1			
WEIGHT 2			
WEIGHT USED			

TANK SOUNDINGS ATTACHED ? __________________

SOUNDING TABLES ATTACHED ? __________________

CURVES OF FORM ATTACHED ? __________________

RIGHTING MOMENT CURVES ATTACHED ? ___________

DRAW DIAGRAM SHOWING WEIGHT LOCATIONS AND DISTANCES

DATA FORM 12B

RADIUS OF GYRATION EXPERIMENT

VESSEL ______________________ DATE ______________

RECORDER ______________________ LOCATION ______________

START TIME ______________________ FINISH TIME ______________

DRAFTS

FWD __________ AFT __________

GM _____ HOW WAS GM OBTAINED ? ______________________

TANK SOUNDINGS ATTACHED ? ______________________

WAS DATA RECORDED ? ________ OR PERIOD TIMED ? ________

DATA DISK/TAPE NUMBER ______________________

TEST RUN NUMBERS ______________________

TIMES

TRIAL NUMBER	TIME	# OF CYCLES (PORT TO STBD TO PORT)
1	______	______________
2	______	______________
3	______	______________
4	______	______________
5	______	______________

TEST NUMBER 13

MOTION IN WAVES

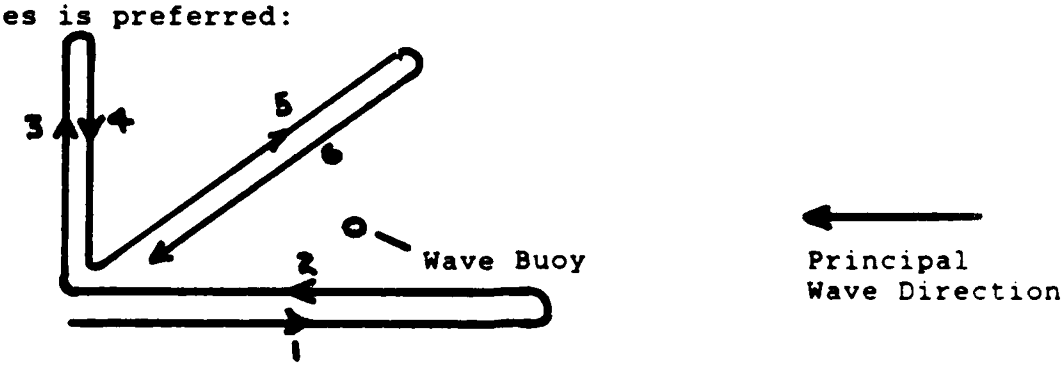
OBJECTIVE

To determine the response amplitude operators of the vessel to waves. This may be required for all six degrees of freedom. Also to be determined are the significant wave height $H_{1/3}$ and corresponding significant motions.

PROCEDURE

This test requires that a motion package capable of measuring the motions desired as well as appropriate recording equipment be placed aboard the test vessel. A method of measuring wave amplitudes in the test area is also required. This is usually accomplished by placing a wave buoy in the water and recording its motions during the time interval of the test.

The vessel is to be operated on courses which will produce head seas, astern seas, beam seas, seas broad on the bow, and seas broad on the quarter. Ship motions will be recorded for each of these directions over a 20-minute period. Wave height from the wave buoy will also be recorded. The vessel should remain as close to the wave buoy as possible. The following pattern of courses is preferred:



The tests will be conducted for one speed and one operating configuration. Additional speeds and operating configurations can be specified. The maximum vessel speed and preferred operating configuration for that speed will be used if no variation is specified.

MEANS OF DETERMINING DATA

The motion package should contain a gyroscopic reference to horizontal and a fixed horizontal (yaw) angle reference. Ship angular motions are measured relative to these fixed references. The angles are:

The angles are:

roll - about longitudinal axis
pitch - about athwartships axis
yaw - about vertical axis

The same fixed reference should be used to measure accelerations or velocities relative to an "earth" reference. This is the preferred method. Accelerations or velocities relative to a "ship" reference are also an accepted way to conduct the test. Linear motions to be measured are

heave - vertical direction
sway - athwartships direction
surge - longitudinal direction

Wave buoy data is usually in the form of vertical motion. This may be an acceleration of velocity but should be integrated over time to provide a vertical buoy displacement which is taken to equal the wave height variation with time.

PARAMETERS VARIED AND HELD CONSTANT

Water depth is not critical to this test but should be at least five times the draft of the vessel. Wave height should usually be between two to six feet for vessels in the 100- to 200-foot range. Two to four foot seas are recommended for testing small boats. Too small a wave height produces small motions and too large a wave height produces non-linear response. Wind and current have only a small effect on the results. Testing in a well developed sea is preferred.

Vessel speed and operating configuration will be held constant for each series of courses. Additional series may be conducted for different speeds or configurations. Speed may be set to sufficient accuracy using shaft RPM. Course and speed should be maintained for at least 20 minutes on each leg to provide sufficient data for analysis.

The following data is to be collected:

1. Wave height versus time
2. Vessel motions versus time - roll, pitch, yaw, heave, sway, and surge
3. Water depth
4. Operating configuration
5. Shaft RPM
6. Apparent wave direction
7. Vessel course
8. Draft and trim of vessel
9. Wind speed and direction
10. Location of motion package

INSTRUMENTATION REQUIRED

1. Wave buoy with necessary recording and telemetry equipment. A wave staff may also be used if suitable.
2. Motion package capable of measuring the desired motions
3. Recording equipment for motion package (analog required)
4. Depth sounder
5. Anemometer for wind speed

DATA FORMS

Data Form 13A is to be used to record data not stored on tape.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

Wave and motion data will be converted from a time to a frequency scale using a spectrum analyzer with a Hanning windowing function. The response amplitude operator (RAO) for each motion will be produced. This RAO is only an approximation to the true RAO for the vessel and must be used with caution in predicting vessel motions under other wave conditions.

Wave heights and motion amplitudes will also be sorted and the value of the 1/3 highest motions or wave heights computed. The 1/10 highest amplitudes will also be presented.

DATA FORM 13A

MOTION IN WAVES

VESSEL NAME ______________________ DATE ____________

RECORDER ______________________________________

OPERATING CONFIGURATION ________________________

____

RPM ________________ SPEED ________________

DRAFT FORWARD __________ DRAFT AFT ______________

APPARENT WAVE DIRECTION ____________ TRUE

WIND SPEED ____________ WIND DIRECTION __________ TRUE

WATER DEPTH ____________ DENSITY ________________

LOCATION OF MOTION PACKAGE ______________________

____

____

RUN #	VESSEL COURSE	DIRECTION TO WAVES	START TIME TAPE COUNT	FINISH TIME TAPE COUNT

DATA DISK/TAPE NUMBER __________________________

TEST NUMBER 14

SURF OPERATIONS

<u>OBJECTIVE</u>

To determine the ranking of a subject vessel's surf handling compared to one or more existing Coast Guard vessels.

<u>PROCEDURE</u>

The suitability of a vessel for the near-shore rescue mission depends on a number of factors such as seakeeping, ruggedness, reliability, etc. This test focuses on the handling aspects of the near-shore rescue mission, and is designed as a comparison between a test vessel and a Coast Guard reference vessel. Suitable reference vessels are the 44 ft MLB and the 30 ft SRB.

At least 3 complete boat crews shall be assembled (one for each test boat plus one extra to be rotated in), **with each crewmember being a qualified Surf Coxswain.** A suitable test location must be chosen to provide challenging surf and inlet conditions. The test vessel and the reference vessel should be thoroughly prepared for the tests so that they are at the peak of their capabilities. A safety vessel should be available at all times and arrangements for rapid response of other Coast Guard resources to any emergency must be made, as the hazards of surf operations cannot be underestimated.

The boat crew personnel should be randomly divided into crews, and assigned to boats. The boats should then undertake a typical surf boat maneuvers such as running in and out of inlets, entering and exiting the surf zone, performing man-overboard drills in the surf and picking up a simulated casualty in the surf. Only one maneuver at a time will be attempted during each test session. The details of each maneuver should be worked out in advance in planning discussions with the boat crews. Once a procedure is decided upon, it should be duplicated as nearly as possible for every test. The maneuver should be duplicated several times by each coxswain, until he feels he is performing the maneuver to the best of his and the boat's capabilities. The other members of the boat crew shall then take turns at the helm, and the maneuvers repeated, until each member of the boat crew has performed the maneuvers. Boat crews should then be changed, and members of the crews re-assigned in a "round robin" fashion, so that the effects of different helmsmen and different crews can be randomized. If possible, testing should be conducted in a variety of different conditions, continuing to re-assign crews and boats.

Different types of boats, while all being suitable for surf rescue, may require different handling techniques to perform the same tasks. Sufficient time to familiarize the boat crews with the subject vessel should be allowed prior to the test sessions,

and instruction from an expert (such as a manufacturer's representative) in the handling of the subject vessel to be sought.

MEANS OF DETERMINING DATA

Upon the completion of each test session, the crew shall score the boats on their ability to perform the session's maneuvers using questionnaire 14. This should be done as soon as the crews return from the session. Discussion of the session should be limited until after the questionnaire has been filled out to avoid influencing each individual's perceptions of the boats.

The usual test condition data shall also be recorded.

PARAMETERS VARIED AND HELD CONSTANT

The factor to be evaluated is the boat; the effect of the crew is minimized by using the "round-robin" assignment of certified/qualified crews and boats. Other conditions are out of the Test Director's control, but surf should be at least 4 ft during the test sessions. The test area must have suitable areas of surf and/or inlet conditions.

The following data is to be collected:

1. Draft and Trim of the vessel
2. Operational Configuration
3. Wave height and direction
4. Wind Speed and direction
5. Current speed and direction
6. Water depth in the test area

INSTRUMENTATION REQUIRED

1. Anemometer for wind speed and direction
2. Depth sounder
3. Hand recording is suitable for all data

DATA FORMS

Data form 14 is to be used to record data on conditions of the test. Questionnaire 14 is to be used to record the boat crew's impressions of each test session.

PHOTO DOCUMENTATION

Video tape records of the boats performing the maneuvers are highly desirable, preferably filmed from a helicopter and with a voice-over narrative describing the boat, the maneuver, and any other relevant information. If there are any significant problems or weaknesses encountered in the handling of the boats, they should be documented with a videotape recording of a demonstration designed to exhibit the boat displaying its particular vice.

ANALYSIS OF DATA

The responses to the questionnaires shall be tabulated and the mean, standard deviation, and variance of each ranking computed for each boat. The statistical significance of each ranking shall be checked by the appropriate method (such as a T-Test), and only statistically significant responses reported. It is suggested that a 90% confidence level be used to judge statistical significance.

DATA FORM 14
SURF HANDLING

VESSEL NAME ______________________ DATE ________________

RECORDER __________________________________

LOCATION ________________________ WATER DEPTH ________

TIME START ______________________ FINISH ______________

OPERATING CONFIGURATION ____

WAVE HEIGHT ________________ WAVE DIRECTION __________________

WIND SPEED _________________ WIND DIRECTION __________________

CURRENT SPEED ______________ CURRENT DIRECTION _______________

DRAFT FWD ________________________ AFT __________________________

COMMENTS ON SURF/INLET CONDITIONS:

QUESTIONNAIRE 14 - SURF HANDLING

VESSEL NAME ______________________________

YOUR NAME ______________________________ DATE ______________

This Questionnaire is designed to evaluate the vessel's ability to perform in the surf environment. Each question asks you to rank the vessel from 1 to 10, 1 indicating low capability (bad) and 10 indicating high capability (good). Answer the questions which you feel are within your experience. Check Not Observed if you do not feel qualified to answer the question or if it does not relate to the maneuver we have just performed. If there are any additional comments you would like to make regarding surf handling, please include them in the Remarks section.

DO NOT DISCUSS THE DAY'S TESTING WITH ANYONE UNTIL YOU HAVE COMPLETED THE QUESTIONNAIRE. IT IS VITAL THAT WE GET YOUR IMPRESSIONS, AND NOT THAT OF YOUR CREW OR OF THE GROUP AS A WHOLE.

IF YOU TESTED MORE THAN ONE BOAT THIS TEST SESSION, FILL OUT A QUESTIONNAIRE FOR EACH BOAT.

TEST MANEUVER FOR THIS SESSION ______________________________

1. What is your rating of the boat's ability to perform this maneuver?

1 2 3 4 5 6 7 8 9 10 not observed

2. What is your rating of the boat's speed capability relative to this
maneuver?

1 2 3 4 5 6 7 8 9 10 not observed

3. What is your rating of the boat's rudder control relative to this
maneuver?

1 2 3 4 5 6 7 8 9 10 not observed

4. What is your rating of the boat's acceleration relative to this maneuver?

1 2 3 4 5 6 7 8 9 10 not observed

5. What is your rating of the boat's rolling motions relative to this maneuver?

1 2 3 4 5 6 7 8 9 10 not observed

QUESTIONNAIRE 14 - SURF HANDLING (cont'd)

6. What is your rating of the boat's heaving and pitching motions relative to this maneuver?

1 2 3 4 5 6 7 8 9 10 not observed

7. What is your rating of the boat's yawing motions relative to this maneuver?

1 2 3 4 5 6 7 8 9 10 not observed

8. What is your rating of the boat's forgiveness of error relative to this maneuver?

1 2 3 4 5 6 7 8 9 10 not observed

9. What is your rating of the visibility from the helm relative to this maneuver?

1 2 3 4 5 6 7 8 9 10 not observed

10. What is your rating of the deck arrangement relative to this maneuver?

1 2 3 4 5 6 7 8 9 10 not observed

11. Your safety depends on the capabilities of this vessel. Assign a confidence rating to it, taking in all the test sessions thus far.

1 2 3 4 5 6 7 8 9 10 not observed

TEST NUMBER 15

SEAKEEPING ABILITY - PHYSIOLOGICAL

OBJECTIVE

To measure and interpret aspects of boat's motion which may be a physiological burden to its crew.

PROCEDURE

A) Vertical accelerations are to be measured when the boat is underway in head seas running 2-4 feet high.

   1) With a vertical accelerometer mounted in the boat's pilothouse.

   2) With a human response vibration meter mounted in the vicinity of the vertical accelerometer in 1).

   If there is reason to believe that other locations on the boat (such as the engine room) may contribute larger values of acceleration, then these areas should also be measured.

B) Rolling motion may be measured by a motion package near the boat's center of gravity, or it may be measured in the pilothouse with a viscously damped inclinometer connected to a tape recorder for permanent record purposes.

C) Pitching motion may be measured by a motion package near the boat's center of gravity, or it may be measured in the pilothouse with a viscously damped inclinometer connected to a tape recorder for permanent record purposes.

D) Measure and record sea spectrum, boat's heading and speed.

PARAMETERS TO BE MEASURED AND HELD CONSTANT

A) Vertical accelerations are to be measured (minimum) and recorded in the frequency range 0.1-80 HZ (See Data Form 15A).

B) Concurrently, with A) above, measure accumulative vibration level as measured by a human response meter (such as Bruel & Kjaer Type 2512 Meter and Printer Type 2312).

C) Periodically, the human response meter is switched to measure acceleration in the Y (abeam) direction, and also in the X (fore and aft) direction.

D) Roll and Pitch are to be measured and recorded concurrently with accelerations.

All of the above is to be recorded on a multi-channel/tape recorder so that analysis of the data may be accomplished at a later date.

DATA ANALYSIS

Data is to be analyzed as shown on Data Form 15A. Any other data obtained is to be summarized and correlated with data which has undergone frequency analysis in order to determine if any inferences can be derived from the data obtained.

DATA FORM 15A

SEAKEEPING ABILITY - PHYSIOLOGICAL

VESSEL NAME ______________________________ DATE ______________

LOCATION OF ACCELEROMETER ______________________________

NAME AND MODEL OF ANALYZER ______________________________

ANALYST NAME ______________________

Heave Motion Analysis (1-80 Hz)

Center-Band HZ	3rd Octave Passband	$(RMS)^2$	RMS	Mult X	Weight Factor	RMS_w	$(RMS_w)^2$
1.0	0.89-1.12				.50		
1.25	1.12-1.41				.56		
1.60	1.41-1.78				.63		
2.00	1.78-2.24				.71		
2.50	2.24-2.82				.80		
3.15	2.82-3.55				.90		
4.00	3.55-4.47				1.0		
5.0	4.47-5.6				1.0		
6.3	5.62-7.08				1.0		
8.0	7.08-8.91				1.0		
10.0	8.91-11.2				0.8		
12.5	11.20-14.1				0.63		
16.0	14.10-17.8				0.50		
20.0	17.80-22.4				0.40		
25.0	22.40-28.2				0.315		
31.5	28.20-35.5				0.25		
40.0	35.50-44.7				0.20		
50.0	44.70-56.2				0.16		
63.0	56.20-70.8				0.125		
80.0	70.80-89.1				0.10		

*See International Standard ISO 2631-1978(E), Table 3

Total $(RMS_w)^2$ = ________

Total RMS_w = ________

Motion Sickness Analysis (.1-1.0Hz)

Center-band Hz	3rd Octave passband	$(RMS)^2$	RMS
0.1	.089-112		
0.125	.112-.141		
0.16	.141-.178		
0.20	.178-.224		
0.25	.224-.282		
0.315	.282-.355		
0.4	.355-.447		
0.5	.447-.566		
0.63	.566-.708		
0.8	.708-.891		
1.0	.891-1.12		

TEST NUMBER 16

SUSCEPTIBILITY TO SLAMMING

OBJECTIVE

To determine the frequency of slam during runs at various speeds.

PROCEDURE

Tests will be conducted into waves of sufficient heights to cause slamming of the bow. A range of speeds will be used to determine slam frequency versus speed for constant sea condition and operating configuration. The test can be repeated for different operating configurations and sea states. All tests will be conducted with head seas.

MEANS OF DETERMINING DATA

Accelerometers will be installed in the bow of the test craft as near the bottom of the hull as possible. The data from these accelerometers will be continuously recorded during each run. Counters which are set to measure accelerations above a certain level can also be used.

PARAMETERS VARIED AND HELD CONSTANT

Operating configuration and sea state will be the constants in this evaluation. Wave height should be sufficiently high to cause the vessel to experience slamming. Wind, water depth, and current conditions are not critical to this test.

Speed will be varied into the seas. The vessel will run at each speed for a sufficient time to accurately determine the frequency of slamming. The time required will depend on how many slams are occurring and hence on the sea state.

The following data is to be collected:

1. Bow vertical acceleration versus time
2. Wave height
3. Operating configuration
4. Shaft RPM
5. Draft and trim of the vessel

INSTRUMENTATION REQUIRED

Accelerometers and analog recording instrumentation or acceleration level counters.

DATA FORMS

Data Form 16A or 16B will be used to record data not stored on analog tape.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

Bow acceleration data is to be run off on a strip chart and the number of slams in a given period of time counted. Results will be presented in the form of a plot of slam frequency versus speed for each configuration tested. The plots will be annotated with wave height, operating configuration, and draft.

DATA FORM 16A

SUSCEPTIBILITY TO SLAMMING

VESSEL NAME ______________________________ DATA ________________

RECORDER ________________________________

EST. WAVE HEIGHT __________________ LOCATION ____________________

____

OPERATING CONFIGURATION ____

____

DRAFT FORWARD ____

AFT ____

RUN NUMBER*	SHAFT RPM	DATA TAPE NUMBER

*NOTE: IF ACCELERATION LEVEL COUNTERS ARE USED, RECORD DATA ON DATA FORM 16B.

DATA FORM 16B

SUSCEPTIBILITY TO SLAMMING

VESSEL NAME ______________________________ DATA ________________

RECORDER ______________________________

EST. WAVE HEIGHT ________________ LOCATION ____________________

____

OPERATING CONFIGURATION ____

____

DRAFT FORWARD ____

AFT ____

RECORD THE READINGS FROM THE STATISTICAL SHOCK LEVEL COUNTERS BELOW

RUN NUMBER	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
	_____G's	_____G's	_____G's	_____G's
INITIAL	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

TEST NUMBER 17

PERFORMANCE IN ASTERN SEAS

OBJECTIVE

To determine vessel maneuverability in astern seas.

PROCEDURE

The zigzag maneuver described in Test 9 will be conducted in a significant sea state (three to eight feet for WPB or larger, two to four feet for small boats). Base course will be with the waves (astern seas) and vessel speed should be significantly less than the wave speed. The other procedures of Test 9 are to be followed.

MEANS OF DETERMINING DATA

Same as for zigzag maneuver in Test 9.

PARAMETERS VARIED AND HELD CONSTANT

Same as Test 9.

INSTRUMENTATION REQUIRED

Same as Test 9.

DATA FORMS

Data Form 9A is to be used for data not stored on computer disks or tape.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

Data will be presented as described in Test 9 for the zigzag maneuver. It is recommended that Test 9 also be conducted in order to compare the results. Any significant effect on maneuverability caused by astern seas should be apparent from the results.

TEST NUMBER 18

WATERTIGHT INTEGRITY

OBJECTIVE

To obtain the floodable length curve of the vessel and to ship check each bulkhead for watertight integrity.

PROCEDURE

The floodable length curve for the vessel is to be obtained from the vessel's builder or owner. This curve provides data necessary to determine compartment standards for vessel and points out any watertight integrity problem areas. Bulkheads which were assumed watertight in developing the floodable length curves should be ship checked visually and/or by pressurizing the compartment to insure that they truly are watertight bulkheads and that the as-built configuration has not defeated their purpose.

DATA FORMS

No forms are required but discrepancies in watertight integrity must be documented.

PHOTO DOCUMENTATION

Discrepancies found should be documented with photographs as well as in writing.

ANALYSIS OF DATA

The floodable length curve will be provided together with any discrepancies in watertight subdivision discovered.

TEST NUMBER 19

OPERATIONAL CAPABILITIES

OBJECTIVE

To obtain operator's evaluations of the vessel in performing the operational missions assigned.

PROCEDURE

The following evolutions will be performed several times under their prescribed conditions:

Man Overboard Recovery

An "Oscar" dummy will be used to simulate the pick-up of an unconscious victim. Average wave height shall be recorded on Questionnaire 19A.

Towing

A second vessel within the towing capabilities of the test vessel will be picked up in tow in a moderate sea state. Average wave height during the test shall be recorded on Questionnaire 19B.

Boarding Operations

A second vessel will be boarded by a crewman off the test vessel in a calm to moderate sea state. Wave height and factors which affect the safe transfer of boarding members shall be recorded on Questionnaire 19C.

Helo Operations

In a calm to moderate sea state helo operations shall be conducted by transferring "Oscar" from the test vessel to a helicopter using a Stokes litter. Average wave height shall be recorded on Questionnaire 19D.

MEANS OF DETERMINING DATA

Crew members will be given a questionnaire following the completion of the operational evolutions.

DATA FORMS: Questionnaires 19A, 19B, 19C and 19D will be used.

PHOTO DOCUMENTATION: Videotape recordings of the evolutions should be performed whenever possible, preferably from a helicopter.

ANALYSIS OF DATA: Responses will be collated and significant points will be emphasized.

QUESTIONNAIRE 19 - MAN OVERBOARD RECOVERY

VESSEL ______________________________ DATE ____________

EVALUATOR ______________ AVG WAVE HEIGHT ______________

This questionnaire covers some aspects of the vessel's ability in recovering victims, conscious and unconscious, from the water. Answer the questions you feel are within your experience. Check **"Not Observed" if you do not feel qualified to answer the question or if it does not apply.** If there are additional comments you would like to make regarding other points of victim recovery, you may include them in the Remarks section.

1. Ability of the vessel to maintain a heading into the surf.

   Excellent Good Satisfactory Poor Not Observed

2. Visibility of the victim in the water while making the approach.

   Excellent Good Satisfactory Poor Not Observed

3. Ability of the vessel to maintain a position next to the victim.

   Excellent Good Satisfactory Poor Not Observed

4. Ease of recovering the victim from the water.

   Excellent Good Satisfactory Poor Not Observed

5. Ease of communications between coxswain and pick-up crewmen.

   Excellent Good Satisfactory Poor Not Observed

6. Was the vessel's freeboard a factor in making recovery of the victim from the water difficult?

   Yes No

7. Is there a lack of handrails or other safety features available for the crew to assist in picking up the victim?

   Yes No

8. Do appendages or other aspects of the vessel make recovery of the victim more dangerous?

   Yes No

9. Remarks. Comment on specific details of the vessel's capabilities which assisted or hindered recovery of the victim in the water. Be sure to comment on any question where you rated this boat as poor or where you answered "Yes" concerning a problem area. Are there improvements which could be made to the vessel to make the operation easier?

QUESTIONNAIRE 19B - TOWING OPERATIONS

VESSEL ______________________ DATE __________

EVALUATOR ______________ AVG WAVE HEIGHT ______________

This questionnaire covers some aspects of the vessel's towing capability. Answer the questions you feel are within your experience. Check "Not Observed" if you do not feel qualified to answer the question. If there are additional comments you would like to make regarding other points of the towing operation, you may include them in the Remarks section.

1. How would you rate the overall towing ability?

   Excellent   Good   Satisfactory   Poor   Not Observed

2. Towing bitt location (astern tow).

   Excellent   Good   Satisfactory   Poor   Not Observed

3. Cleat location (side tow).

   Excellent   Good   Satisfactory   Poor   Not Observed

4. Visibility for maneuvering close to tow.

   Excellent   Good   Satisfactory   Poor   Not Observed

5. Visibility when towing.

   Excellent   Good   Satisfactory   Poor   Not Observed

6. Available power.

   Excellent   Good   Satisfactory   Poor   Not Observed

7. Maneuverability with tow.

   Excellent   Good   Satisfactory   Poor   Not Observed

8. Docking with tow.

   Excellent   Good   Satisfactory   Poor   Not Observed

9. Communications with crew handling towline.

   Excellent   Good   Satisfactory   Poor   Not Observed

10. Were differences in gunwale height a problem for side tows?

    Yes   No

QUESTIONNAIRE 19B - TOWING OPERATIONS (cont'd)

11. Does the propeller cavitate or aerate?

    Yes No

12. Did problems occur with the towline?

    Yes No

13. Were there any problems associated with towing in the surf?

    Yes No

14. Remarks. Include any comment you have concerning this boat. Be sure to comment on any question where you rated this boat as poor or where you answered "Yes" concerning a problem area. Be specific in your comments. Could improvements be made to the vessel to make towing easier?

QUESTIONNAIRE 19C - BOARDING OPERATIONS

VESSEL ______________________________ DATE ____________

EVALUATOR ________________ AVG WAVE HEIGHT ________________

This questionnaire covers some aspects of the vessel's boarding capability. Answer the questions you feel are within your experience. Check "Not Observed" if you do not feel qualified to answer the question. If there are additional comments you would like to make regarding other points of the boarding operation, you may include them in the Remarks section.

1. How would you rate the vessel as a boarding platform?

   Excellent Good Satisfactory Poor Not Observed

2. Maneuverability alongside another vessel

   Excellent Good Satisfactory Poor Not Observed

3. Fendering system of the boat.

   Excellent Good Satisfactory Poor Not Observed

4. Stability of the platform.

   Excellent Good Satisfactory Poor Not Observed

5. Communications with boarding party.

   Excellent Good Satisfactory Poor Not Observed

6. Weapons storage.

   Excellent Good Satisfactory Poor Not Observed

7. Deck lighting?

   Excellent Good Satisfactory Poor Not Observed

8. Remarks. Include any comment you have concerning this boat. Be sure to comment on any question where you rated this boat as poor or where you answered "Yes" concerning a problem area. Be specific in your comments. Could improvements be made to the vessel to make boardings easier?

QUESTIONNAIRE 19D - HELO OPERATIONS

VESSEL ______________________________ DATE ____________

EVALUATOR ________________ AVG WAVE HEIGHT ________________

This questionnaire covers some aspects of the vessel's helo support capability. Answer the questions you feel are within your experience. Check "Not Observed" if you do not feel qualified to answer the question. If there are additional comments you would like to make regarding other points of the helo support operation, you may include them in the Remarks section.

1. How would you rate the vessel in performing helo operations?

   Excellent Good Satisfactory Poor Not Observed

2. Was it difficult to maintain position under the helicopter?

   Yes No

3. Were there any obstructions which interfered with the stokes litter?

   Yes No

4. Were there any problems associated with transferring the victim to the helicopter?

   Yes No

5. Were there any problems with communications between helmsman, pilot, and crewmen working on deck?

   Yes No

6. Is adequate lighting for night operations provided ?

   Yes No

7. Remarks. Include any comment you have concerning this boat. Be sure to comment on any question where you rated this boat as poor or where you answered "Yes" concerning a problem area. Be specific in your comments. Could improvements be made to the vessel to make helo operations easier?

TEST NUMBER 20

ADVERSE WEATHER OPERATION

OBJECTIVE

To evaluate the vessel's capability to operate in adverse weather conditions.

PROCEDURE

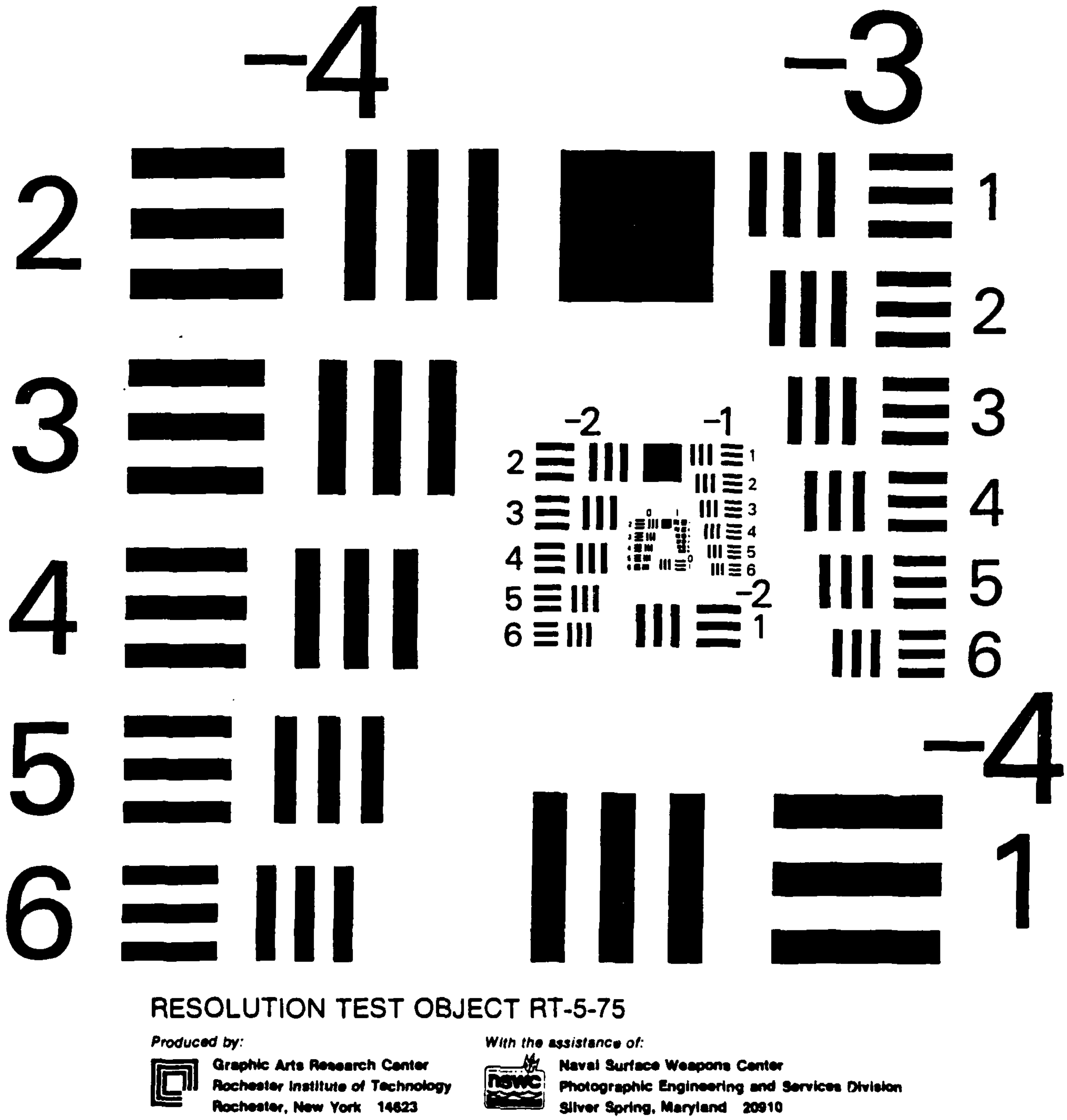
The vessel will be placed inside an environmental chamber which is capable of controlling the temperature and humidity and simulating conditions of rain or icing. Alternatively, test sites with the appropriate climatic conditions may be used with slight changes in procedure. Testing will cover the following three problem areas of adverse weather operations:

Visibility from Pilothouse

The first test will evaluate how rapidly and effectively spray and water can be cleared from the pilothouse windows. This test will be conducted at ambient temperature. The chamber will be darkened and a standard Naval Bar Chart (see Figure 20-1) will be illuminated by an outdoor AC spotlight with a 100-watt bulb positioned 3' in front of it. The bar chart will be positioned 25' from the pilothouse windows. Rain should be produced covering an area from the bow of the vessel up to the pilothouse windows and extending 5' beyond the beam of the vessel on either side. Wind, generated at a speed 10 mph greater than the vessel's maximum speed, will drive the rain against the pilothouse windows. The intensity of the rain will commence at 1/2" per hour and be increased until the bar chart is no longer clearly visible from inside the pilothouse with the windshield wipers and/or rearview screens operating. This will be recorded on the data sheet. The generated wind speed will then be decreased in 5 mph increments until the bar chart is entirely visible.

The second test will evaluate the ability of the vessel to de-fog the windows. The maximum number of personnel authorized shall be placed in the crew compartment to ensure a moisture source for frost/fog formation. The air temperature will be lowered and humidity increased gradually until the de-fogging system can no longer keep the windows clear. This will be determined by use of the bar chart as in the previous test. The temperature and humidity conditions (both inside the vessel and outside) where the de-fogging system is ineffective will be recorded.

The third test will evaluate if visibility can be maintained under icing conditions. This will be achieved by lowering the temperature of the chamber and applying rime ice to the windows until ice accumulates at a rate of 1/4" per hour. The icing rate



-4
-3
2
3
4
5
6
1
2
3
4
5
6
-2
-1
2
3
4
5
6
1
2
3
4
5
6
-2
1
-4
1
RESOLUTION TEST OBJECT RT-5-75
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Rochester Institute of Technology
Rochester, New York 14623
With the assistance of:
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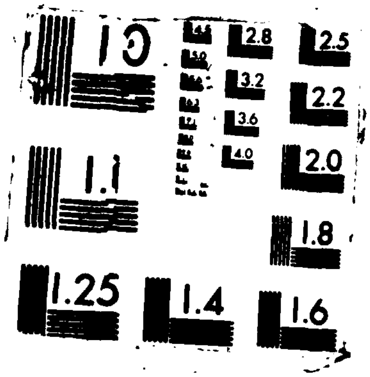
Naval Surface Weapons Center
Photographic Engineering and Services Division
Silver Spring, Maryland 20910

FIGURE 20-1

AD-A183 654 SMALL BOAT TEST PLAN(U) COAST GUARD RESEARCH AND DEVELOPMENT CENTER GROTON CT C A KOHLER ET AL. APR 87 CGR/DC-11/87 USCG-D-14-87 2/2

UNCLASSIFIED F/G 13/10 NL


1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

shall then be increased. The temperature and icing rate at which de-icing is no longer possible (i.e., the transparent areas of the crew compartment are completely obscured) will be recorded.

An alternative procedure for de-icing evaluation can be conducted without facilities for simulating ice formation. The transparent areas of the craft should be marked with a grease pencil or felt-tip pen into a grid of equal sized squares. With the external temperature 0 degrees F or below, water is sprayed onto the glazing until an even coating of 1/4" of ice is applied. The heater/defroster is then operated until no further clearing is observed and the percentage of the glazed area cleared is recorded.

The final test determines the ability of the windshield washers and wipers to clear salt spray from the pilothouse windows. The transparent areas of the craft should be marked with a grease pencil or felt-tip pen into a grid of equal sized squares. Salt water is to be sprayed on the windows and allowed to dry. The windshield washers and wipers are then operated for one minute and the portion of the transparent area cleared is recorded.

Deck Equipment Operation

As much of the deck equipment as possible will be operated at a temperature of no higher than 0 degrees F. Any discrepancies will be noted.

Cold Cranking of the Main Engines

Before the chamber is cooled, the engine will be started and run for twenty minutes to verify that all systems are operating properly. Engine fluids shall be those specified by the manufacturer or the Coast Guard for use in winter conditions.

The chamber will then be cooled to the specified temperature (0 degrees F if not specified) and 50% relative humidity. The vessel will be maintained at those conditions for at least 6 hours or until all components are within 4 degrees F of the test temperature before attempting to start the main engines. A fully charged, cold-soaked battery shall be used for each attempt. The manufacturer's starting procedure will be followed and the starter engaged continuously for no longer than 60 seconds during each attempt. If an engine will not start on any attempt, it shall be started using heat, starting fluid, etc., allowed to warm up and then cold-soaked again before making another attempt. Similarly, if the engine starts successfully, allow it to reach normal operating temperature before shutting down and re-cooling for the next attempt. The number of successful attempts necessary for satisfactory performance will be determined by the Test Director.

PARAMETERS VARIED AND HELD CONSTANT

The key parameters in the testing such as temperature, humidity, wind speed, rainfall intensity, and icing rate are all controlled by the environmental chamber. Other variables such as heater outlet temperature, engine oil sump temperature, raw water temperature, etc., shall be recorded. See the references for detailed guidelines.

DATA FORMS

Form 20A is to be used to record the data. Temperatures of equipment, etc., can be recorded manually or electronically.

PHOTO DOCUMENTATION

35 mm still photographs will be taken during each increment of the visibility tests.

REFERENCES

U.S. Army Test and Evaluation Command (TECOM) Test Operation Procedures (TOP):

Title	TOP #	NTIS Accession #
Aircraft Defogging and Defrosting	7-3-522	ADA 056976
Vehicle Personnel Heater Compatibility	2-2-708	ADA 090590
Climatic Chamber Testing	7-3-521	ADA 074049
Engine Cold-Starting and Warmup Tests	2-2-650	ADA 089535
Rain and Freezing Rain	2-2-815	ADA 029317

DATA FORM 20A

ADVERSE WEATHER OPERATION

VESSEL NAME ______________________________ DATE ____________

RECORDER ____

VISIBILITY FROM PILOTHOUSE (TEST 1):

TEMPERATURE ________ RELATIVE HUMIDITY ________ WIND SPEED ________

RAIN INTENSITY	VISIBILITY (SAT/UNSAT)	WIND SPEED	VISIBILITY (SAT/UNSAT)

VISIBILITY FROM PILOTHOUSE (TEST 2):

AMBIENT TEMPERATURE ________ RELATIVE HUMIDITY ________

CREW COMPARTMENT TEMP ______ RELATIVE HUMIDITY ______ TIME ______

CREW COMPARTMENT TEMP ______ RELATIVE HUMIDITY ______ TIME ______

CREW COMPARTMENT TEMP ______ RELATIVE HUMIDITY ______ TIME ______

CREW COMPARTMENT TEMP ______ RELATIVE HUMIDITY ______ TIME ______

CREW COMPARTMENT TEMP ______ RELATIVE HUMIDITY ______ TIME ______

CREW COMPARTMENT TEMP ______ RELATIVE HUMIDITY ______ TIME ______

VISIBILITY FROM PILOTHOUSE (TEST 3):

AMBIENT TEMPERATURE __________ RELATIVE HUMIDITY __________

ICING INTENSITY (INCHES/HR)	VISIBILITY (SAT/UNSAT)

PERCENTAGE OF TRANSPARENT AREA CLEARED ________________

DATA FORM 20A

ADVERSE WEATHER OPERATION

DECK EQUIPMENT OPERATION:

LENGTH OF COLD SOAK ___________

TEMPERATURE ___________ RELATIVE HUMIDITY ___________

DISCREPANCIES ____

____

____

____

COLD CRANKING OF ENGINES:

DESCRIPTION OF TEST RESULTS ____________________________________

____

____

____

____

____

____

____

____

____

____

____

____

TEST NUMBER 21

ANCHORING

OBJECTIVE

To determine the ability of the vessel to anchor, riding ability at anchor, and the maximum force at which the anchor will hold.

PROCEDURE

The vessel will be anchored several times in different weather conditions. After each evolution, the crew members involved will fill out a questionnaire on the various aspects of the evolution. The direction which the vessel rides relative to the wind the seas, and to the anchor line will be recorded as well.

MEANS OF DETERMINING DATA

Data will be obtained through direct observation and questionnaires filled in by the crew.

PARAMETERS VARIED AND HELD CONSTANT

Anchoring will be conducted in various weather conditions to determine limitations. The following data is to be collected.

1. Wave height and direction
2. Wave speed and direction

INSTRUMENTATION REQUIRED

Anemometer for wind speed and direction.

DATA FORMS

Form 21A will be used by the test director for recording observations of anchoring. Questionnaire 21B will be filled by the ship's crew.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

Important observations and crew comments will be summarized in the report.

DATA FORM 21A

ANCHORING

VESSEL NAME ______________________________ DATE ______________

RECORDER ______________________________

TIME START ____________________ LOCATION ______________________

FINISH ____

WAVE HEIGHT _________________ RELATIVE WAVE DIRECTION __________

WIND SPEED _____________ RELATIVE WIND DIRECTION _____________

COMMENTS ____

QUESTIONNAIRE 21B

ANCHORING

VESSEL NAME ____

YOUR NAME ____________________________ DATE _________________

TIME ON BOARD _________________________

This questionnaire covers some of the aspects of anchoring which are difficult to measure. Answer the questions which you feel are within your experience. **Check Not Observed if you do not feel qualified to answer the question or if it does not apply to your vessel.** If there are additional comments you would like to make regarding anchoring, you may include them in the Remarks section. This questionnaire is intended to be filled out immediately after an anchoring evolution.

1. What is your estimate of the wave height during the anchoring?

   Wave height __________ feet

2. Were there any significant problems related to the anchoring?

   Not Observed ______ No ______ Yes ______

3. If so, were the problems related to the:

   Anchor ______ Anchor windlass ______
   Shape of the hawse ______
   Chain stoppers or Anchor Chain _____
   Similar equipment ______
   Other (explain) ______________________________________

4. Describe briefly what the problems were.

   ____
   ____
   ____
   ____
   ____
   ____
   ____

ANCHORING

5. Do you feel there is a risk of damaging hull appendages while anchoring? These could include foils, air cushion seals, etc.

   Not observed ______ No ______ Yes ______

6. If yes, what items are in risk of damage?

   ____

   ____

7. Describe the vessel's ride at anchor

   Excellent Good Satisfactory Poor Not Observed

8. Do you feel there is a risk of damage to hull appendages while riding at anchor?

   Not observed ______ No ______ Yes ______

9. If yes, what items are in risk of damage?

   ____

   ____

11. Overall, how do you compare the ease of anchoring this vessel to MLB?

    Not observed ______ About the same ______

    Much easier ______ More difficult ______

    Easier ______ Much more difficult ______

12. What was the primary reason for the ease of anchoring being easier or more difficult?

    ____

13. Remarks. Includes comments on any aspects of anchoring not covered in the questions above which you feel are important.

    ____

    ____

TEST NUMBER 22

TIME TO GET UNDERWAY

OBJECTIVE

To determine the time required to get the vessel underway from a normal in-port condition in a situation requiring rapid response.

PROCEDURE

The object of this test is to find how fast the crew can get the vessel underway in an urgent situation such as a SAR call. The craft will begin in a basically dead plant condition on shore ties if possible. It is important that the crew be well trained in their duties. The objective of the test is to measure the vessel's performance and not the crew's; delays caused by the crew still learning their jobs should be avoided. The principal measurement will be the elapsed time from first notification until the vessel departs the dock. It is advisable to record the time of other significant events taking place during the process of getting underway. These include:

- Notification of test start
- Main engines started
- Shore ties disconnected
- Engineering plant ready to get underway
- Operations ready to get underway
- Deck ready to get underway

A SAR incident can be fabricated for this test. For small boats where the crew would normally be in the ready room upon notification of an actual incident, the crew should be onboard, or at least on the dock before the test is started. The distance from the coffee pot to the boat is not an important test parameter.

MEANS OF DETERMINING DATA

The only data required is the time of occurrence of various events. These may be determined from observations (preferred) or from logged events in the deck and engineering logs.

PARAMETERS VARIED AND HELD CONSTANT

None. This test should be an unrehearsed measurement of a typical time to get underway.

DATA FORMS

Form 22A will be used for recording data for this test.

PHOTO DOCUMENTATION, ANALYSIS OF DATA

None required. Times will be reported as they occurred.

DATA FORM 22A

TIME TO GET UNDERWAY

VESSEL NAME ______________________________ DATE ____________

RECORDER ______________________________

1. INITIAL NOTIFICATION ______________________________

   MAIN ENGINE STARTED ______________________________

   SHORE TIES DISCONNECTED ______________________________

   ENGINEERING PLANT READY TO GET UNDERWAY ____________

   OPERATIONS PLANT READY TO GET UNDERWAY ____________

2. VESSEL LEAVES DOCK (LAST MOORING LINE IN) ____________

   TOTAL ELAPSED TIME: ITEM 2, MINUS ITEM 1 ____________

3. COMMENTS: (LIMITING FACTORS, HAZARDS, ETC.)

____

____

____

____

TEST NUMBER 23

HULL VIBRATIONS LEVEL

OBJECTIVE

To determine the vibration level of the primary hull structure at a small number of key points.

PROCEDURE

The vibration of the main hull structure will be determined in this test. A small number (6 or less) of vibration pickups will be installed in locations around the vessel. Pickups will be secured near hard points in the structure such as deck bulkhead intersections so as to measure the vibration of the whole hull structure locally. Secondary vibrations such as local plating vibrations are not of interest. Pickups will normally be positioned at intervals along the main deck from the bow to the stern and near the pilot house. Vibrations data should be collected in calm water over a range of speeds from idle to full ahead and from idle to full astern. Zero speed vibrations should also be recorded. Additional data may be collected in actual operations in a variety of sea conditions. If two or more significantly different operating configurations are possible, vibration measurements should be made for each.

MEANS OF DETERMINING DATA

A small number of vibration pickups will be used. These may sense either accelerations or velocities in the vertical direction.

PARAMETERS TO BE USED AND HELD CONSTANT

In the calm water trials the vessel should be operated with normal equipment on line. Speed is to be varied by changing the SRPM in steps. Vertical vibrations of the primary structure only will be measured.

Wave conditions for the calm water portion of the tests must not exceed 1 foot. Wind and current should have little effect on the results. Water depth must be greater than five times the draft.

The following data is to be collected:

1. Hull vibrations
2. SRPM
3. Operating configurations
4. Draft and trim
5. Wave height
6. Location of vibration pickups
7. Water depth

INSTRUMENTATION REQUIRED

1. Vibration pickups with amplifiers
2. Analog tape recorder
3. Shaft RPM counter
4. Depth sounder

DATA FORMS

Data Form 23A will be used to record data not stored on analog tape.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

Data will be processed by a spectrum analyzer to produce curves of vibration amplitude versus frequency. No other vibration analysis is required. The amplitude and frequency of the most severe vibrations at each location will be noted.

DATA FORM 23A

HULL VIBRATIONS LEVEL

VESSEL NAME ______________________ DATE __________

RECORDER ______________________

LOCATION OF TEST ______________________

OPERATING CONFIGURATION ______________________

____

DRAFT FWD __________
AFT __________

WAVE HEIGHT __________ WATER DEPTH __________

LOCATION OF PICKUPS

#1 ______________________

#2 ______________________

#3 ______________________

#4 ______________________

#5 ______________________

#6 ______________________

____

____

SRPM'S USED (LIST)

____

____

____

____

DATA TAPE(S) USED # __________

TEST RUN NUMBERS

____

____

TEST NUMBER 24

NOISE LEVEL

OBJECTIVE

To survey the entire vessel and record noise levels in each compartment and at selected locations on the exterior decks.

PROCEDURE

Sound level measurements are to be made with both A and C weightings. A measurement will be made at the center of each compartment and at every position used by the crew. This includes every compartment except voids, fuel and water tanks, chain lockers and similar spaces. In the engine room, additional locations may be designated. Sound measurements will also be made at a number of locations on exterior decks.

Sound levels will be taken with the vessel traveling at full speed with normal equipment operating. Additional speeds and operating configurations may be specified.

Sea and weather conditions are not critical in this test. However, data should not be taken in extreme wind and wave conditions which may cause a lot of noise themselves.

MEANS OF DETERMINING DATA

A hand-held noise level meter will be used and the data hand recorded.

PARAMETERS VARIED AND HELD CONSTANT

Ship speed and operating configuration should be constant during the period of the survey. Changes in equipment on line should also be avoided. The following data is to be recorded:

1. Compartment name or location
2. Sound level on A and C weighting in decibels
3. SRPM
4. Operating configuration
5. Wave height
6. Wind speed

INSTRUMENTATION REQUIRED

1. Sound level meter with A and C scale weightings
2. Anemometer for wind speed.

DATA FORMS

Data form 24A is to be used to record all data.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

Raw data will be tabulated by compartment. If additional speeds or operating configurations are specified, the data will be tabulated together for comparison purposes.

DATA FORM 24A

NOISE LEVEL

Vessel Name ______________________________ Date ____________

Recorder ________________________________

Operating Configuration _____________________________________

____

Shaft RPM ____________________ Speed _________________

Wave Height __________________ Wind Speed _________________

Compt. or location	A Weighting dB	C Weighting dB

TEST NUMBER 25

VISIBILITY FROM THE PILOTHOUSE/COXSWAIN FLAT

OBJECTIVE

To determine the area of visibility from each of the primary operator positions.

PROCEDURE

A transit or theodolite will be positioned at each principal operators position in the pilot house and the field of view will be surveyed in terms of both horizontal and vertical angles. A height of eye of 5'6" above the pilot house deck will be used unless seats are provided which would change the height of eye. The actual height of eye will be approximated in those cases.

Principal operators stations will be determined by the location of seats or other bridge equipment. If positions are not apparent as in the case of a roving deck operator then three positions spaced across the bridge width will be used.

MEANS OF DETERMINING DATA

Field of view from each operating position will be completely mapped out in terms of vertical and horizontal angles. The limits to this field of view include the window frames, the bow or stern of the vessel or any deck fixtures which interfere with a clear line of sight. A transit or theodolite must be used to measure the angles accurately.

PARAMETERS VARIED AND HELD CONSTANT

None. Angles will be measured with the vessel at the dock.

INSTRUMENTATION REQUIRED

Transit or theodolite

DATA FORMS

Data Form 25A is to be used to record data from these tests.

PHOTO DOCUMENTATION

A series of still photographs should be taken from each position measured. These photographs should cover the 360 degrees horizontal arc measured and should show the total field of view. Photographs are to be taken with instant camera film or other print film.

ANALYSIS OF DATA

The 360 degrees horizontal cylinder will be unrolled (developed) and the vertical angles limiting the field of view will be shown as a function of the horizontal angles. The fraction of total clear viewing area from +15 to -20 degrees will be calculated. This fractional area can be used to compare different vessels.

DATA FORM 25A

VISIBILITY FROM THE DECKHOUSE/COXSWAIN FLAT

VESSEL NAME ______________________________ DATE ________________

RECORDER ________________________________

SKETCH IN AREA MEASURED INDICATING DATA POINTS BY NUMBER

ANGLE __________ ANGLE __________

DATA POINT NUMBER	HORIZONTAL ANGLE	VERTICAL ANGLE	DATA POINT NUMBER	HORIZONTAL ANGLE	VERTICAL ANGLE

TEST NUMBER 26

FIREFIGHTING CAPABILITIES

OBJECTIVE

To insure that the vessel's fire pump operates at the rated capacity.

PROCEDURE

A single section of fire hose, most commonly 1-1/2 or 2-1/2 inch diameter, will be attached to the vessel's firemain system at the hose station farthest from the fire pump. A flow meter/pressure digital readout instrument is attached to the end of the fire hose. A standard Navy all-purpose nozzle shall be attached to the discharge side of the instrument. If additional hose is needed to reach a drainage area, it shall be added between the instrument and the nozzle. If this is not possible, as in the case of a fire monitor system, a flow meter should be installed inline somewhere along the system. The fire pump should be brought up to test speed and the flow rate measured. If a pressure gauge is attached to the discharge side of the pump, these readings should also be recorded. The pump will be operated at several speeds beginning with speeds less than the rated speed, including the rated speed, and finishing with speeds higher than rated speed.

MEANS OF DETERMINING DATA

Whenever possible, a digital readout instrument should be used. An alternative method is use of a stopwatch and a 55-gallon drum. The elapsed time taken to fill the drum will determine the discharge rates.

PARAMETERS VARIED AND HELD CONSTANT

For each test run the pump shaft RPM should be held constant while the flow rates are being measured. The same fire hose and discharge orifice should be used for all the tests.

The following data is to be collected:

1. Pump shaft RPM
2. Discharge pressure (if gauge is present in psi)
3. Flow rate (in gallons per minute)

INSTRUMENTATION REQUIRED

1. A digital readout flow meter/pressure gauge.
or
1. A chronometer or stopwatch accurate to one second
2. A large container (55-gallon drum).
or
2. An in-line flow meter (if fire hose attachment isn't possible).

DATA FORMS

Form 26A is to be used to record the data.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

From the data collected, curves will be produced showing flow rate as a function of pump RPM and discharge pressure as a function of flow rate if a pressure gauge is installed.

The flow rate of the pump at rated pump RPM will be used to determine whether the pump was installed properly. The curves will be used to produce a pump operation envelope, a range of speeds where the pump will deliver required pressure and flow rate.

DATA FORM 26A
FIREFIGHTING CAPABILITIES

VESSEL NAME ______________________________ DATE ____________

RECORDER ____

PUMP SPEED (RPM)	FLOW RATE (GPM)	DISCHARGE PRESSURE (PSI)
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________

ARE THERE ANY RESTRICTIONS ON ENGINE SPEED OR MANEUVERING DUE TO OPERATIONS OF THE FIRE PUMPS ? ______________________________

____

____

____

____

TEST NUMBER 27

HELM AND THROTTLE RESPONSE

OBJECTIVE

To assess the response of a vessel's control systems.

PROCEDURE

Throttle Response

This test is somewhat similar to the quick pickup procedure of test 7. The boat is initially at rest with the engines idling and the clutch disengaged. As quickly as possible, the throttles are advanced and the clutches engaged. If the engine stalls, the test is repeated with a slower advance. The time it takes to physically advance the throttles is noted, along with the time to reach maximum rated engine RPM. When the engines heave reached maximum RPM, the throttles are retarded, and the gears (or propellers on a CRP installation) reversed, until full throttle in reverse is reached. The trials are then run with the opposite sequence so the vessel goes from full astern to full ahead. Repeat runs are conducted and the times averaged. If the trim of the propulsion unit is adjustable, it should be varied and the tests re-run.

Helm Response

Since the flow of water over the rudder may affect the moment and the power required to shift the rudder, this test should be conducted underway at a reasonable maneuvering speed. The angle from rudder stop to stop should be measured with a protractor prior to conducting this test. With the helm initially centered, the helm is shifted to hard over as rapidly as possible, and the time noted. The rudder is then brought from stop to stop the other direction and that time is noted. After centering the rudder, the test is performed starting in the opposite direction from the initial test.

On larger vessels, they may be a lag between the time the helm is put over and the time the rudder moves to hard over. It may be necessary to instrument both the helm and the rudder (or other steering unit) to fully describe the response of the control system in this case.

U-turn Maneuver

Proceeding at the fastest reasonable maneuvering speed, the vessel makes a 180 degree course change as quickly as possible. It would be prudent to conduct the Maximum Maneuvering Speed test before attempting this test. The time is noted from the first helm movement to settling down on the reciprocal course. Repeat runs are conducted and the times averaged.

MEANS OF DETERMINING DATA

The time to complete each maneuver shall be measure using a stopwatch and manually recorded

PARAMETERS VARIED AND HELD CONSTANT

The operating condition of the vessel shall be typical for it's designed mission. Wave height, wind speed and current should be minimal, but they will not have a large effect on the results.

The following data is to be taken:

1. Success or failure of each maneuver
2. Time to complete the maneuver
3. Engine RPM or throttle setting
4. Draft and Trim of the vessel
5. Operational Configuration
6. Wave height and direction
7. Wind Speed and direction
8. Current speed and direction
9. Water depth

EQUIPMENT REQUIRED

1. Stopwatch
2. Anemometer for wind speed and direction
3. Depth sounder
4. Hand recording is suitable for all data

DATA FORMS

Form 27 is used to record the data.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

The time to complete each maneuver should be presented as an average. The Rudder Rate, and Turning Rate should be computed for the Helm Response and 180 Degree Turn Maneuver, respectively.

DATA FORM 27
HELM AND THROTTLE RESPONSE

VESSEL NAME ______________________ DATE ____________

RECORDER ____________________________

LOCATION ________________________ WATER DEPTH ______

TIME START ______________________ FINISH ___________

OPERATING CONFIGURATION ______________________________

DRAFT FWD _______________ AFT ______________________

WAVE HEIGHT ______________ WAVE DIRECTION ___________

WIND SPEED _______________ WIND DIRECTION ___________

THROTTLE RESPONSE

RUN NUMBER	____	____	____	____	____
NEUTRAL TO FULL AHEAD	____	____	____	____	____
FULL AHEAD TO FULL ASTERN	____	____	____	____	____
NEUTRAL TO FULL ASTERN	____	____	____	____	____
FULL ASTERN TO FULL AHEAD	____	____	____	____	____
STALL ?	____	____	____	____	____

HELM RESPONSE

RUN NUMBER	____	____	____	____	____	____
CENTER TO STBD LOCK	____	____	____	____	____	____
LOCK TO LOCK	____	____	____	____	____	____
CENTER TO PORT LOCK	____	____	____	____	____	____
LOCK TO LOCK	____	____	____	____	____	____

U-TURN MANEUVER

RUN NUMBER	____	____	____	____	____
RPM	____	____	____	____	____
TIME TO TURN 180 DEG	____	____	____	____	____

TEST NUMBER 28

MANEUVERING SPEED

OBJECTIVE

To determine the safe maneuvering speed for:

1. Boats that are 20 feet or more in length and capable of a top speed of 35 mph (30 knots) or more using manufacturers' rated horsepower.

2. Boats that are less than 20 feet in length and capable of a top speed of 30 mph (25 knots) or more using manufacturers' rated horsepower.

PROCEDURE

The boat should be rigged as close as possible to its operational condition. Boats with permanently installed fuel tanks shall be no more than one-half full. Outboard boats without permanent fuel tanks should be tested beginning with one full portable tank for each motor. Portable tanks should be in their designated location or placed as far aft as practicable. The use of the following safety equipment is required during testing because of the potential for exceeding the capabilities of the boat while performing this test.

1. Type I or II PFD
2. Crash helmet
3. Emergency Ignition Stop Switch

Quick Turn Test

To conduct a Quick Turn Test, the driver operates the boat straight ahead at a given throttle setting, beginning with 1/2 maximum throttle. The wheel is turned 180 degrees in one direction in 1/2 second or less and held at that position without changing the throttle or trim settings during or after the wheel change. The boat completes the maneuver successfully if it is capable of completing a 90 degree turn without the driver's loss of confidence in maintaining control.

If the boat successfully completes the Quick Turn Test, increase the boat's entry speed incrementally until the boat does not complete the test or successfully completes it at maximum throttle. The highest speed at which the boat successfully completes the Quick Turn Test is the maneuvering speed.

Test Course Method

The test course, as shown in Figure 28-1, should begin with the boat's throttle set a 1/2 maximum throttle. A minimum of three consecutive runs are made in each direction, passing

Boat Capacity Test Course

35 M.P.H. to 50 M.P.H.

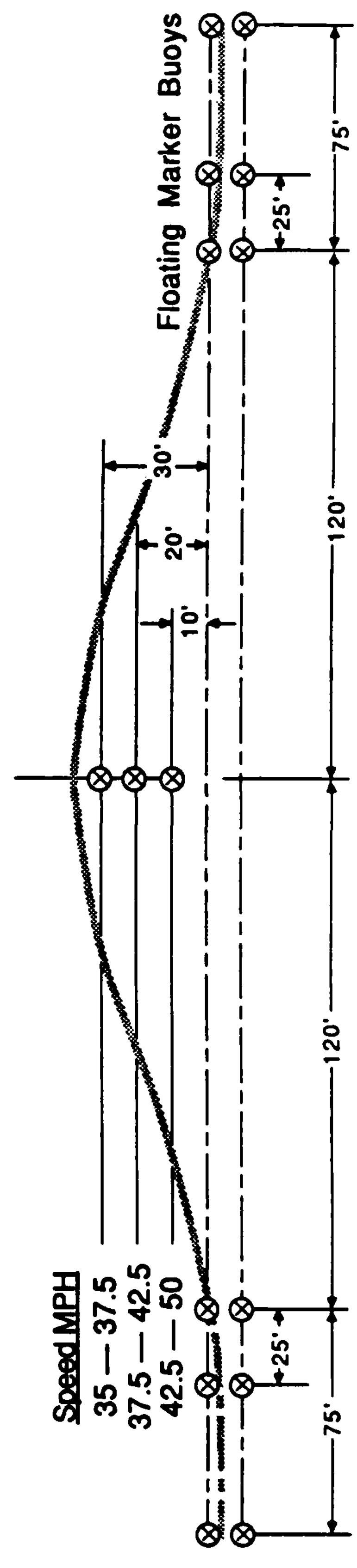


FIGURE 28-1

outside the designated avoidance marker without contacting any of the course markers. Increase the throttle setting by five mph increments until the maximum speed at which the boat successfully completes the course is determined. This speed is the maximum maneuvering speed.

It is recognized that operator skill and familiarity with the boat will affect the test results. It is therefore considered permissible to make a number of practice runs through the test course at any throttle setting. During testing there should be no change in the positions of any equipment or personnel. The tests shall be terminated upon evidence of oscillating motion in the roll or yaw axes while negotiating the course.

MEANS OF DETERMINING DATA

Speed, the most important factor in this test, will be measured with an installed speedometer or radar speed gun. The maximum full throttle speed will be verified by radar or by the average of not less than two passages over a measured course in both directions.

PARAMETERS VARIED AND HELD CONSTANT

Testing should be conducted on smooth, calm water with the wind speed below 10 knots. No additional loads other than a driver who weighs no more than 200 lbs will be aboard the boat. The motor trim angle should be adjusted to provide maximum full throttle speed short of excessive porpoising or propeller ventilation so that there is no loss of directional control.

INSTRUMENTATION REQUIRED

1. Speedometer, accurate to 1 mph, if possible.

2. Radar speed gun, for vessels where installation of speedometer would be difficult or impossible.

DATA FORMS: Form 28A is to be used to record the data.

PHOTO DOCUMENTATION: Data is also recorded photographically from an angle as directly above the test course as possible. Video or motion picture photography is the desired method to evaluate the vessel's motion during the Quick Turn and Test Course maneuvers.

ANALYSIS OF DATA: The only analysis required in this test is to determine the maximum maneuvering speed if less than the full throttle speed. This can be obtained from the driver's observations recorded on the data sheet and photographic documentation.

DATA FORM 28A
MANEUVERING SPEED

VESSEL NAME ______________________________ DATE ____________

FULL THROTTLE SPEED ____________________________________

Quick Turn Test:

Throttle Setting	Vessel Speed	Test Result (Sat/Unsat)

DATA FORM 28A
MANEUVERING SPEED

VESSEL NAME ______________________ DATE ____________

FULL THROTTLE SPEED ______________________

<u>Quick Turn Test</u>:

Throttle Setting	Vessel Speed	Test Result (Sat/Unsat)

<u>Test Course Method</u>:

Throttle Setting	Vessel Speed	Test Result (Sat/Unsat)

END

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